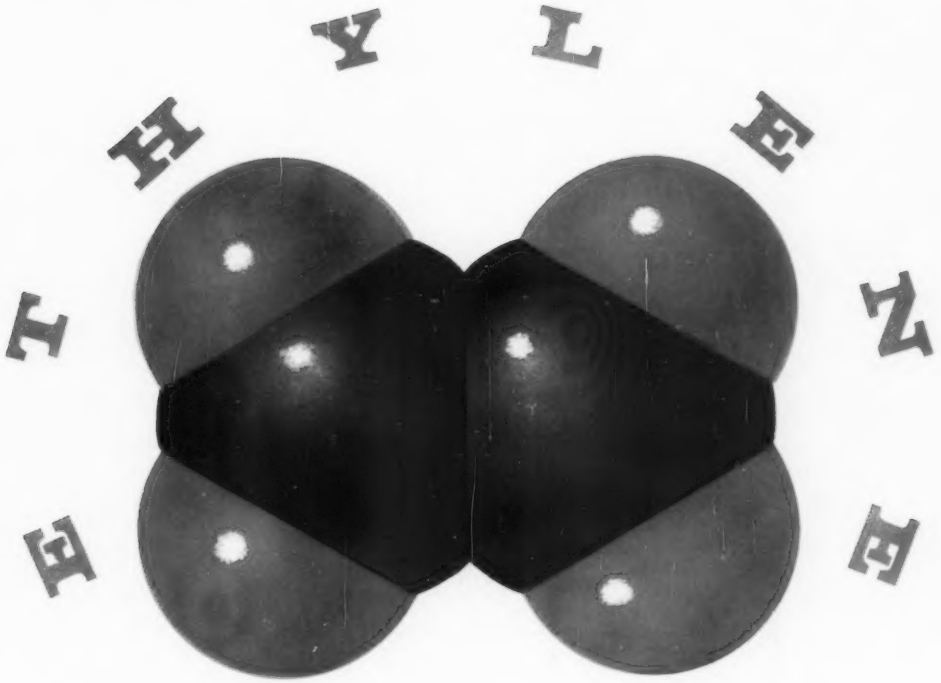
OIL, GAS AND PETROCHEMICAL PROCESSING

Petroleum Refiner

MARCH
1960



What you should know

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NEW DATA

Better Cat Feed by Extraction 145

MAINTENANCE KEY

PM Controls Equipment Failure 177

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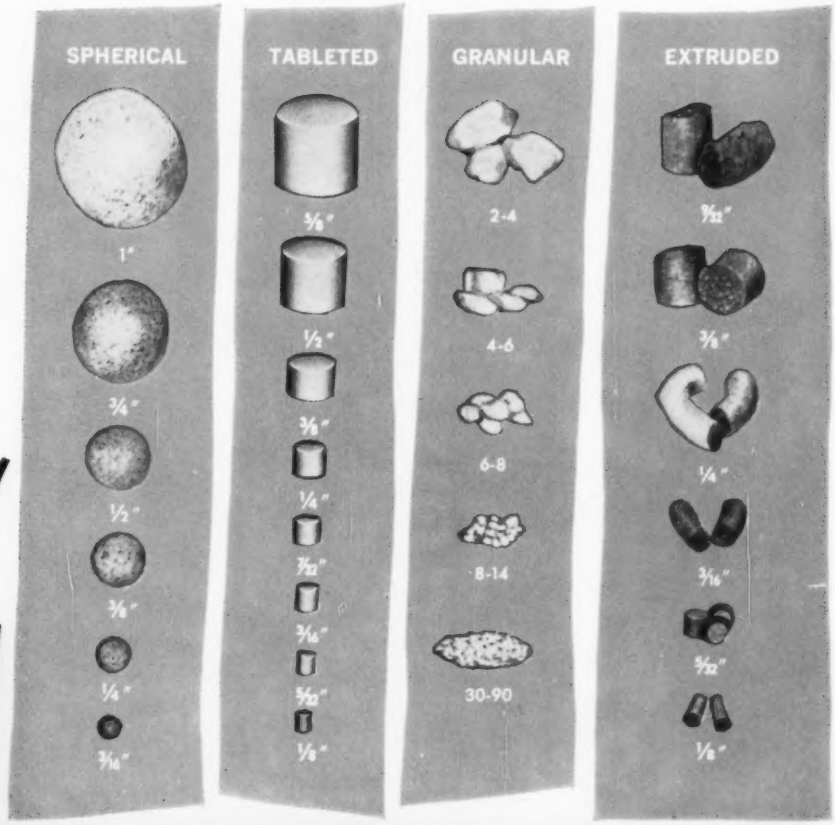

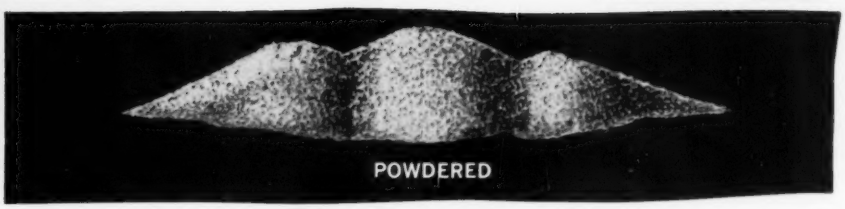

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Volume 39, No. 3 March 1960

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Petroleum
Refiner
OIL, GAS AND PETROCHEMICAL PROCESSING
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A Quick Look at This Issue

These handy digests permit checking the articles you want to read first. ☑

☐ **Ethylene—What You Should Know . . .** Complete knowledge of this important building block can mean success or failure to your petrochemical future. In this Special Report, the techniques of cracking, purification and separation along with descriptions of commercial manufacturing processes are backed up with an extensive bibliography. For current and future reference, turn to **Page 125.**

☐ **Better Cat Feed By Solvent Extraction . . .** More gasoline is made during catalytic cracking when phenol extraction is added to the virgin feedstock pretreatment. The valuable data in this article will show you a two year payout after taxes for a phenol extraction unit treating decarbonized oil. See what this process can do for you by turning to **Page 145.**

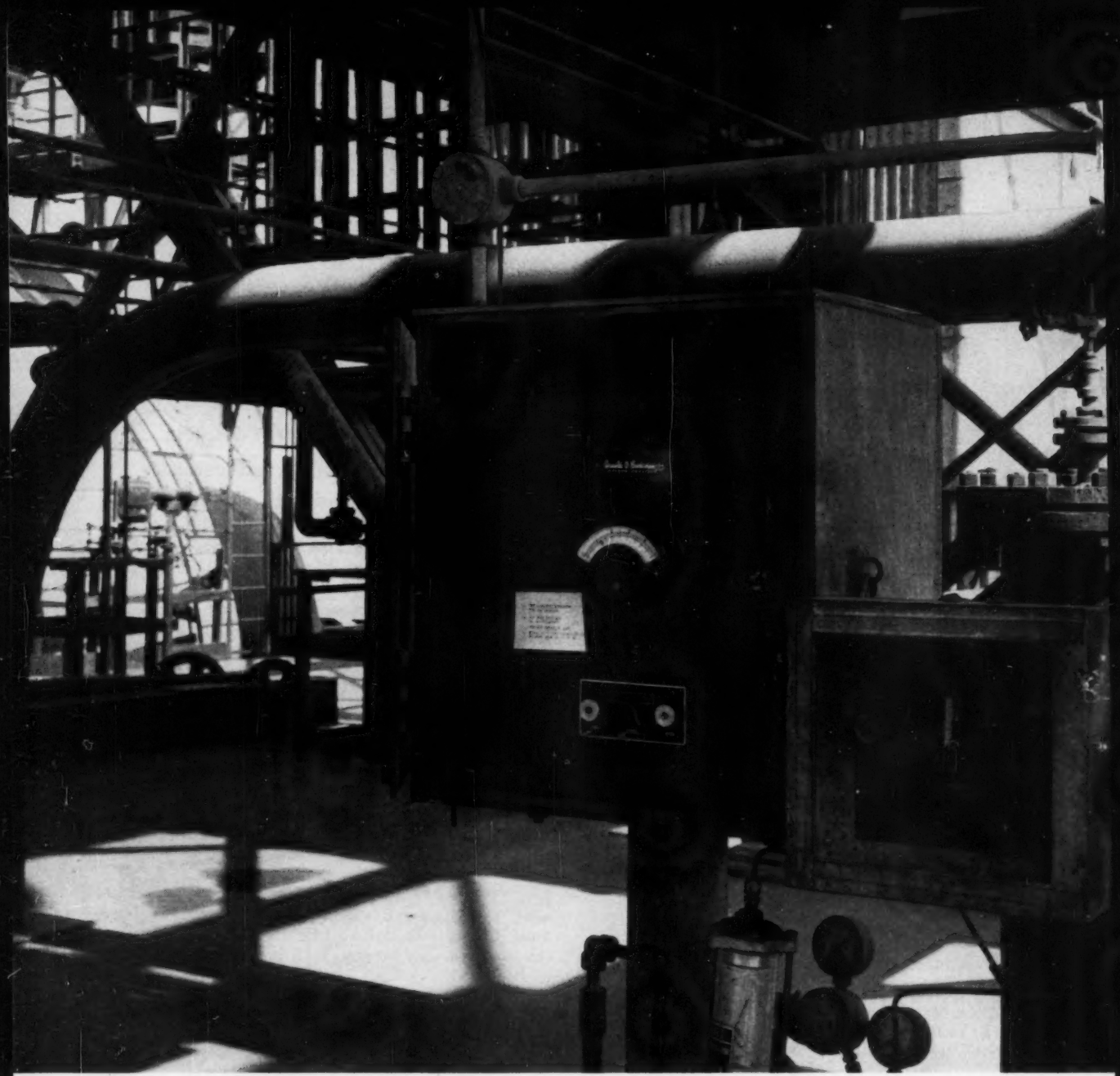
☐ **New Data on Shell's Syn Gas Process . . .** reports for the first time actual commercial operating results. For a look into the unique features of this synthesis gas process, with operating results, turn to **Page 151.**

☐ **Explore Road Ratings Without Test Cars . . .** The relative road performance of motor fuels can be determined now without resorting to expensive test car techniques. The method proposed here is based on a correlation between road ratings of a gasoline and its laboratory octane ratings plus a chemical analysis. Try these equations to rate acceptance of your motor fuel blends. Turn to **Page 153.**

☐ **Make Town-Gas From Refinery Off-Gas . . .** Local requirements for heating gas in England are being met by reforming gases from nearby refineries. Here is how the reforming process works to fulfill the role once held by coal processing. See **Page 159.**

☐ **How to Estimate Installed Pump Costs . . .** Here is a collection of data which permits rapid and accurate estimates of complete process pumping systems. Clip this for your design file, turn to **Page 161.**

Please Turn Page ➔



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A Quick Look at This Issue . . .

☐ **Automation Today, Part 19 . . .** A graphical technique called the root locus plot offers a valuable way to study a process control system. Here is a discussion of the method along with an example of how it works. Turn to **Page 167.**

☐ **Identify the Components of Gasoline . . .** The identity and amount of the chemical components making up olefinic gasolines can now be found by combining the laboratory techniques of super fractionation, chromatography, hydrogenation, and mass spectroscopy. Here are the results on a few typical samples, so be sure to turn to **Page 171.**

☐ **Find Cyclohexane Properties by Nomogram . . .** for another highly useful nomogram giving physical properties of cyclohexane, turn to **Page 176.**

☐ **PM—Key to Equipment Failure Control . . .** Preventive maintenance does not prevent equipment failures but insures you that they will not occur at an uneconomical rate. Here is the Phillips PM program which is not necessarily designed for the lowest maintenance costs, but to keep product costs at a minimum. To check on your own program, turn to **Page 177.**

☐ **Does Fouling Rule Out Using Finned Tubes In Reboilers? . . .** To get additional reboiler capacity, Humble studies show that retubing with finned tubes only costs one-half to one-fifth of that for plain tubes requiring a new shell. In addition, fouling is no more a problem than with plain tubes. For complete details on this study, turn to **Page 183.**

☐ **Now Costs for Hot Carbonate Process . . .** gives the economics of this CO_2 removal process for large installations. For complete plant costs and operating economics, turn to **Page 187.**

☐ **Operator's Handbook for Gasoline Plants . . .** This part on electricity simplifies the theory and application of electrical power in the plant. New and experienced operators will profit from this basic understanding, so turn now to **Page 191.**

☐ **Save Money—Re-use Salt Cooling Water . . .** Here's how California Oil Co. installed salt water cooling towers and saved money on capital investment and maintenance. You'll find some interesting economics in this, so turn to **Page 197.**

☐ **New Japanese Urea Process . . .** Based on excess ammonia, total recycle and higher pressures, this new process gives crystal and prilled urea. For a complete process description, turn to **Page 200.**

☐ **Short Cuts to Tower Foundation Design . . .** V. O. Marshall's article in the May 1958 issue of PETROLEUM REFINER on "Foundation Design For Stacks and Towers" created a new high in reader reprint demand. The present article presents graphic solutions to Marshall's more useful foundation design equations and when used with his article will speed up your calculation time. You'll find your copy of these nomographs on **Page 202.**

☐ **Solubility of Methane in Water . . .** The solubility data in this article are presented at pressures to 500 psia and temperatures from 100° to 250° F. This system exhibits a minimum solubility range. **Page 205.**

☐ **How to Estimate Piping Labor . . .** Here's a method, complete with man-hour tables, to help you quickly estimate piping fabrication and erection costs. Don't guess, clip these tables and be sure, turn to **Page 207.**

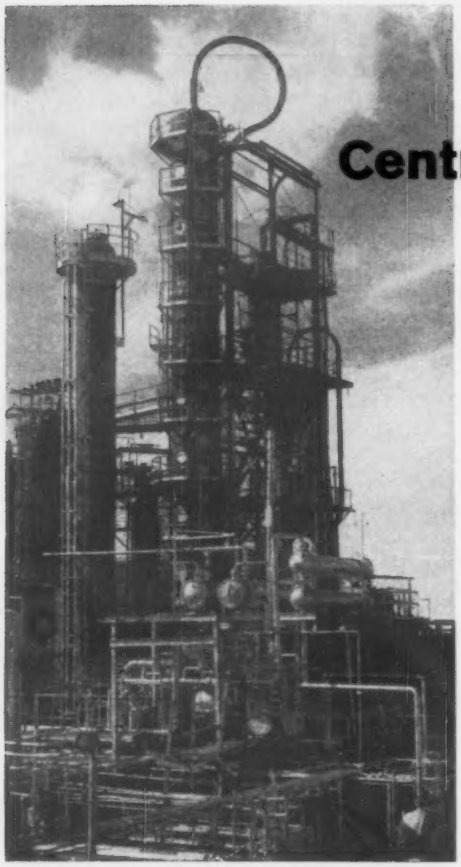
☐ **Graphs Find Vessel Drain Time . . .** Oftentimes you need to make quick estimates of the time required to drain vessels by gravity. These nomographs offer quick solutions to these problems for vertical and horizontal tanks draining through orifices, nozzles or pipe. You'll find the complete details on **Page 213.**

☐ **Charts Speed Pressure Vessel Design . . .** The ASME Unfired Pressure Vessel Code recently made major changes in welded joint efficiencies. It increased the weld joint efficiency to 100 percent for fully radiographed seams, 85 percent for spot radiography and 70 percent for seams not radiographed. There is a chart for each type of weld joint. It's the simple way to find the required shell thickness. For your copy of these handy charts, turn to **Page 217.**

☐ **How to Run a Testing Program . . .** Many management people agree that a good testing program is a valuable tool in the se'ection, placement and evaluation of employes. In order to get the best results, however, there are certain points which you should consider before, during and after launching such a testing program. This article lists those points for you in clear concise language, so be sure to turn to **Page 223.**

☐ **Design Safety Into Your Plant . . .** Fire Safety Economics: Part I . . . Here are some valuable pointers which will help you achieve maximum fire safety in your operations. And as additional benefits, you'll get better employe morale, minimum maintenance costs and lower insurance rates. You're going to find this two-part series valuable for years to come, so be sure you turn to **Page 227.**

☐ **Employe Publications—'Chit Chat' or Management Spokesmen? . . .** Today, many employe publications are completely filled with news of bowling teams, picnics and fuzzy pictures of fishermen and babies. Very seldom, however, is there any effort to explain and interpret the issues vital to the company, to the industry, and to the nation. You'll want to read this frank appraisal of industrial communications starting on **Page 231.**



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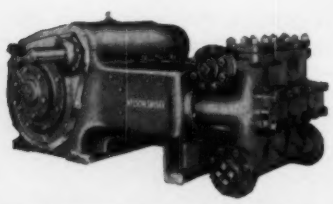
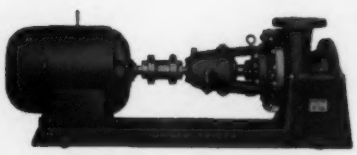
As a manufacturer of both centrifugal and reciprocating types (including both power-driven and direct-acting steam-driven), you can be sure our unbiased recommendation will be the type best suited for your specific applications.

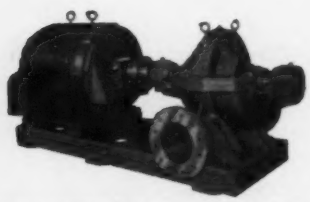
Here are Four Popular Types



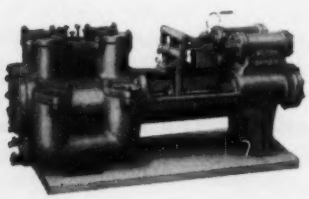
TRIPLEX PLUNGER-TYPE POWER PUMPS . . . Designed for handling a wide range of products, including highly volatile liquids over a wide temperature range, and time-proven in high-pressure charge pump service. Available in 4", 6" and 8" stroke sizes for capacity requirements up to 500 GPM and pressures up to 5,650 psi.



ES CENTRIFUGAL PROCESS PUMPS . . . Single or two-stage heavy-duty type for elevated temperature applications to 900°F., employing vertically split case and single stuffing box for conventional packing or mechanical seal of your choice. End suction, as illustrated, is standard construction—can also be furnished with top suction when preferred. Twenty sizes provide capacities from 15 to 2,000 GPM, 50 to 1100-ft. head, 2 to 250 HP.



DOUBLE SUCTION CENTRIFUGAL PUMPS . . . Single-stage heavy-duty type for temperature applications to 300°F., employing horizontally split case with impeller mounted between bearings. Side suction and side discharge arrangement is standard—bottom suction arrangement is available in 14" and larger sizes. Fourteen sizes provide capacities from 100 to 30,000 GPM, 20 to 300-ft. head, 5 to 1,500 HP.



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Here's The Real Gain

A "HE GOT THE JOB" story fits so nicely into some of the preachment you've seen on this page that we'd like to repeat it:

When a chemical company recently asked bids for an engineering consulting job, six different proposals were submitted. Each of the six was then asked to present some evidence of past work because a long-time arrangement was at stake and the chemical company wanted to be sure it got the right man. One of the applicants chose to send a reprint of an article which he had published in PETROLEUM REFINER back in a late 1957 issue. And to make the story real pretty and, of course, complete, we want to add that this PR author got the job.

We could stop right there, but let's tie it in with that "preachment" reference: There's no better way to add to one's professional prestige than by publishing in a periodical that is highly regarded within the field. So—don't overlook the opportunities of writing and be sure the resulting manuscripts are sent to PETROLEUM REFINER.

And in that connection, you may have a copy of our very helpful Author's Handbook merely by asking. Address PR's Editorial Director, Box 2608, Houston 1, Texas.

April's Special

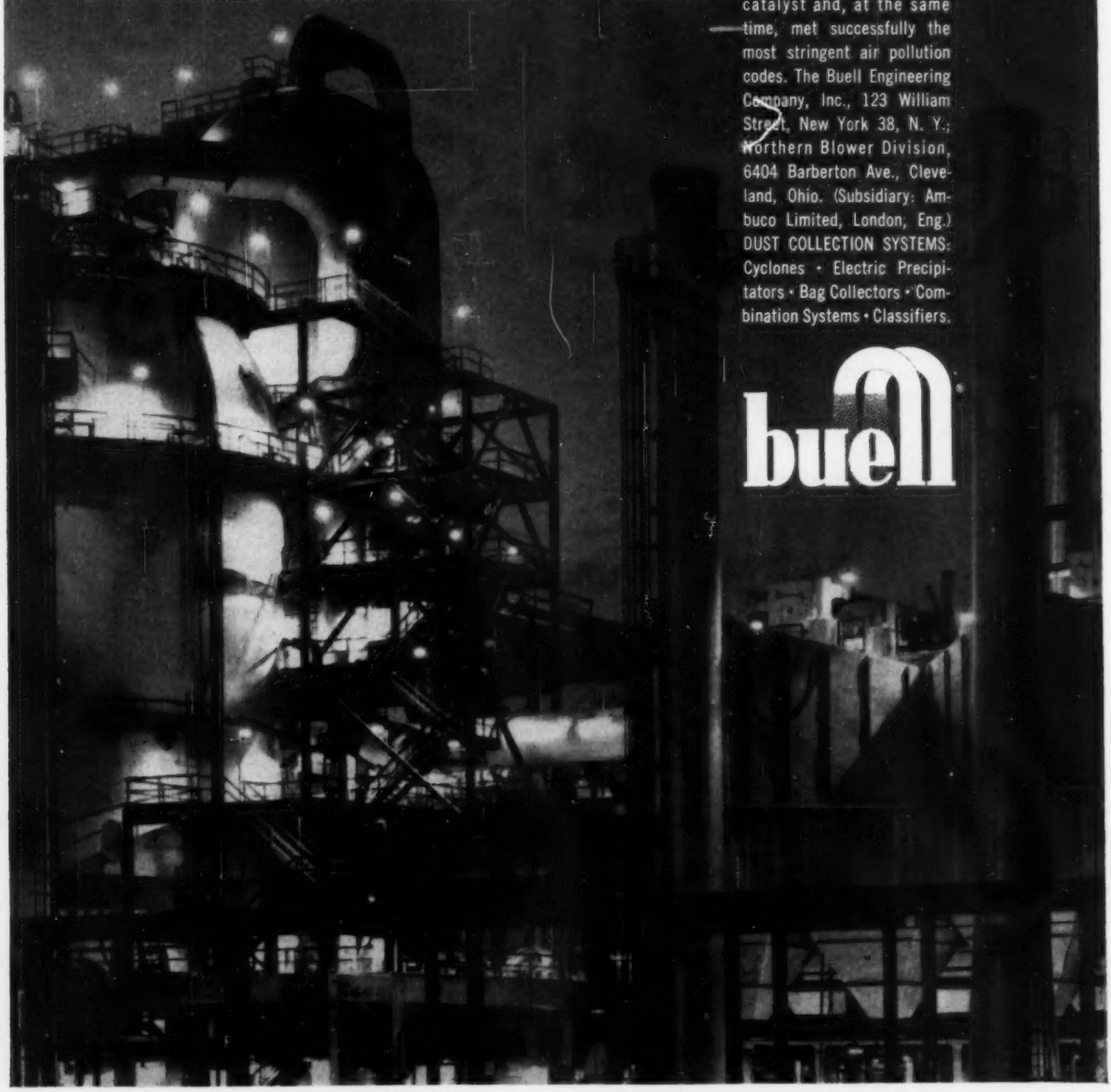
MAYBE THE REASON we're forever telling readers of this page about some upcoming special is that we are forever having something pretty special we'd like them to know about.

Next month it is our annual Natural Gasoline Special Report. PETROLEUM REFINER has more subscribers in this processing field than any other periodical and that's for the very good reason that we pay more attention to natural gasoline activities than any of our contemporaries. For April there will be a careful study on industry trends, a documented piece about how construction costs are being cut, and a number of articles by authoritative writers on topics of timely interest to this phase of the processing industry.

So we would alert our readers for the April issue and promise the natural gasoline people especially a technical section of outstanding interest. It, of course, will have the backing of PR's regular departments plus a goodly quantity of advertising that month after month, we might say, is packed with valuable ideas that make for mighty good reading.

PETROLEUM REFINER **articles which have been reprinted** over the years are listed in a handy catalog which is now available. The listing shows title, author, price, and the articles are classified under general subjects such as Alkylation, Calculation Methods, Catalytic Cracking, Corrosion, Heat Transfer, Instrumentation, Reforming, etc. Address Reprint Department, Petroleum Refiner, Box 2608, Houston 1, Texas for your copy.

ONLY BUELL CYCLONE-PRECIPITATOR COMBINATIONS ARE PROVED BY EXPERIENCE IN THE REFINERY FIELD



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For more data on advertised products, use Readers' Service Cards, last page.

Quick Look at Industry...

Quick Look at Energy Needs . . .

Latest survey of oil and gas supplies available to 1975 shows natural stocks of these energy sources higher than generally estimated. Also, looks like they can be supplied from domestic sources at no appreciably higher constant dollar cost by then. Resources for the Future report also concludes atomic energy will have to come up with significant cost-cutters to compete. Shale oil, too, will exist only on small scale prior to '75.

Butadiene-Based Rocket Fuel Shows Promise . . .

Development work in solid propellents for rockets indicates new butadiene-based propellant has better capabilities than current polyurethane fuel. Shows greater resistance to tear and strain, less tendency to slump, and greater case-bonding capabilities. (More on page 298.)

No Change in Sugar Creek Strike . . .

Seven-month old strike at Indiana Standard's Sugar Creek, Mo., refinery sets new longevity record, but federal mediator says negotiations stand just the way they were. Company claims last offer is best possible and doesn't want to talk until union accepts—Union willing to talk but won't accept offer. Result: continued stalemate.

More Mergers on the Horizon . . .

Look for trend in mergers and oil property acquisitions to continue next few years much like it has for past 5 years. This period saw about 519 complete or partial company acquisitions by 238 acquiring companies. Most frequent reason: to build up crude oil reserves. In the future, biggest change will be increased emphasis on acquiring foreign marketing outlets to dispose of excess foreign crude in light of import quotas. Most recent merger on the scene combines Houston-based Union Oil & Gas Corp. of Louisiana with Texas Natural Gasoline, Tulsa, to form $250-million corp. New firm studying possible expansion into petrochemicals.

Exhaust Devices for all cars? . . .

Rep. Roberts (D-Ala.) tells House that auto makers should include on all '61 cars, new device to reduce air pollution resulting from auto exhaust. Detroit plans to install device on autos slated for sale in smog-troubled California. In reply Auto Manufacturers Assn. claims what's good for Los Angeles not necessarily good for rest of the country—California's smog problems differ from those in other areas of U.S.
Device in question captures fumes escaping from crankcase and returns them to the engine to be burned. Approximate cost: $10 for new cars, $15-$30 for old. (More on page 298).

Army Diesel Wins Over Gasoline . . .

Army Transportation Corps reports multi-fuel diesel engine truck outperformed gasoline-powered truck in road tests. When powered successively by gasoline, JP-4 jet fuel, kerosine, standard diesel and marine diesel, new multi-fuel diesel demonstrated significantly lower

fuel consumption rate than standard gasoline engine. On kerosine or either grade of diesel, contrast was even more pronounced.

Quick Look at World-Wide Construction . . .

Iranian Oil plans $9.8 million, 20,000-bpd cat reformer at Abadan . . . Sinclair Oil and Koppers form new company to build 70-million-lb.-a-year styrene monomer plant in Houston. On stream date: around mid-1961 . . . Largest gas plant in Canada going up south of Edmonton. Owned by 25 companies and operated by British-American, 325-Mmcfd plant due on stream by year's end . . . Ethyl Corp will build vinyl chloride monomer unit at Houston plant—completion slated for early '61 . . . Moroccan government will build 20,000-bpd, $14-million refinery at Mohammadia (formerly Fedala) port, 20 mi. north of Casablanca . . . First unit of UOP Alkar process in U.S. scheduled at Cosden's Big Spring Texas refinery—process makes ethylbenzene . . . India will get 500-ton-a-day urea plant by '63—reportedly world's largest. (More in "Who's Building," page 248.)

Reappraise Octane Ratings . . .

Recent appraisal shows Motor octane ratings more significant than Research method in predicting road performance. Biggest changes occur at high speeds. Also, detrimental influence of olefins almost doubles (full technical report on page 153).
Latest octane postings show premium holding steady previous mark of 99.3 F-1 for January average. Regular is also unchanged at 92.3 F-1.

Stamps Becoming Sticky Issue . . .

Millions of trading stamps from service station purchases by government drivers reportedly piling up in government storage. General Services Administration wants to redeem them for cash, but stamp companies say no—most some will give is half cash, half premiums.

East African Plant Set . . .

First refinery in Mozambique, East Africa will be built by Soc. Nacional de Petroleos. Refining units will include 12,000-bpd crude unit, 2,500-bpd Platformer, 2,000-bpd Unifiner and 1,500-bpd Merox unit. Completion slated for early 1961—Procon (Great Britain) got the contract.

Quick Look Around the World . . .

W. R. Grace acquires controlling interest in Cosden Petroleum . . . Jefferson Chemical buys Warren Petroleum's Conroe, Texas petrochemical plant . . . Cie. Francaise des Petroles will loan $5 million to Asia Oil, Japanese independent now merging with Maruzen's North Japan Oil. Money will be part of $20-million project to reconstruct and expand Asia's Yokohama plant to 30,000 bpd . . .
Soviets now using plywood pipe lines for crude to combat sulfur corrosion in Baku fields . . . International Federation of Petroleum Workers opens regional office in Bogota, Colombia—union's first South American branch.

May Lift Puerto Rican Imports Controls . . .

Look for possible lifting of controls on all oil imports into Puerto Rico —will probably be replaced by reasonable export restrictions to U.S. East Coast. Imports Administrator, Capt. Carson feels present system ignores growing internal demand and possible export market.

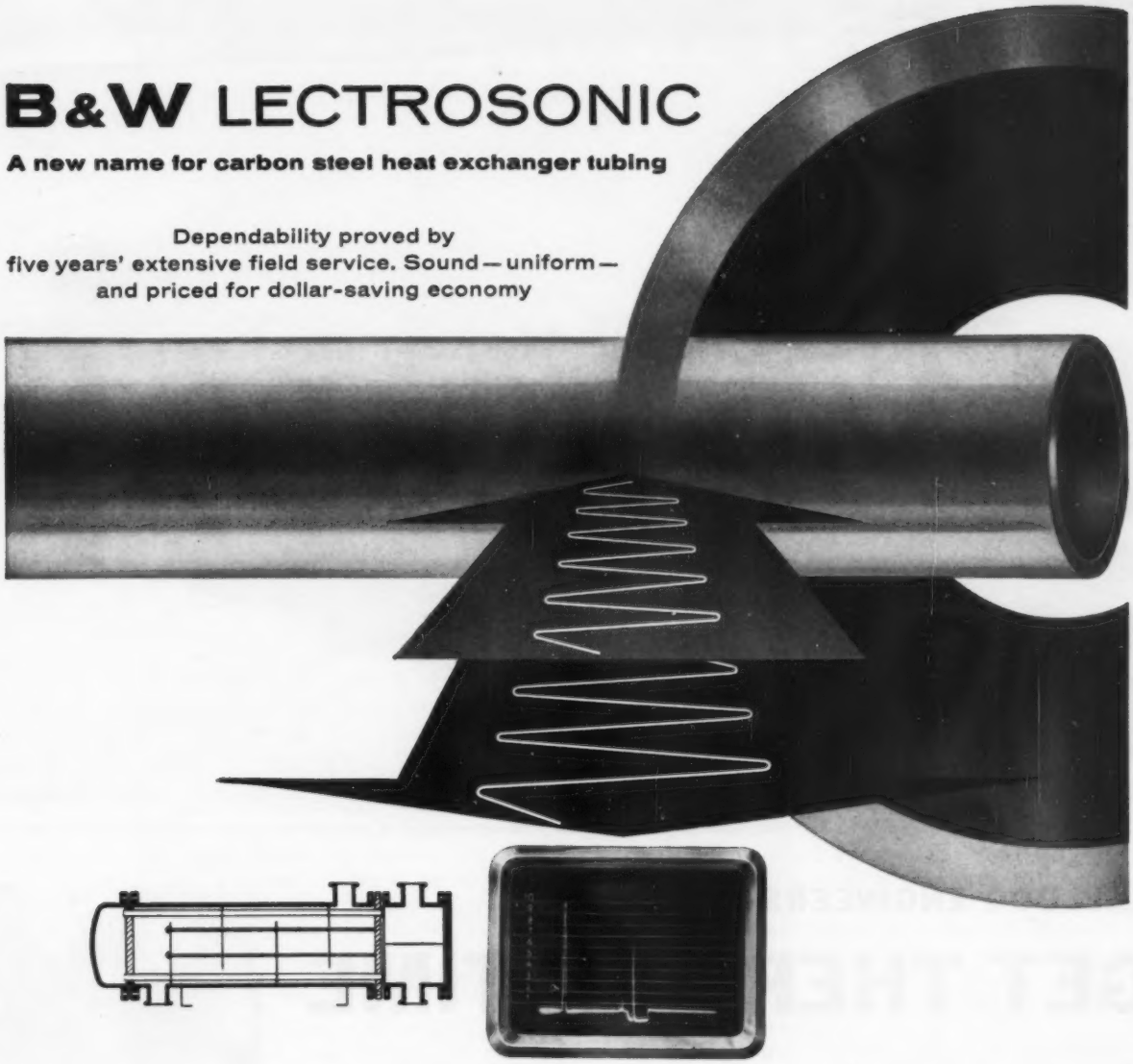
New Entry into Petrochemicals . . .

Bay Petroleum, Tennessee Gas division, enters the petrochemical field with aromatics unit at Chalmette, La., refinery. Cat reformer and extraction plant will be installed as separate facilities. TGT has still another finger in petrochemicals through Petro-Tex Chemical—a joint venture with Food Machinery.

B&W LECTROSONIC

A new name for carbon steel heat exchanger tubing

Dependability proved by five years' extensive field service. Sound—uniform—and priced for dollar-saving economy



Now, B&W brings you a new concept in heat exchanger tubing—B&W LECTROSONIC. Produced under the most exacting quality control methods in the industry, LECTROSONIC tubing fits right, and rolls in easily because it's dimensionally accurate, and uniform.

Continuous ultrasonic inspection—plus destructive and hydrostatic testing, visual inspection, and magnetic particle inspection, are five ways used to check the weld of B&W LECTROSONIC Tubing for your assurance of dependability.

B&W LECTROSONIC Tubing was developed to meet the needs of the petrochemical industry for an electric resistance welded carbon steel tube that is easily workable, strong, and less costly than seamless tubing which it is designed to replace.

Produced in all standard sizes. Available now through distributors or direct from B&W.

Write for B&W Bulletin TB-431 for full information, or call your nearest B&W District Sales Office. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

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THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

Crossing the ice bridge near Fort McMurray, the first of nine plant sections—each on self-contained runners—starts the 35-mile "skid" to the site.

KELLOGG ENGINEERS PLANTS TO

GET THERE ON TIME

A Kellogg characteristic that pays off for clients is getting plants on stream on time. For Cities Service' tar sands project in Northern Alberta, this meant not only designing and building a small diluent recovery and visbreaking plant off-site in record time but shipping it 300 miles by rail, then 35 miles by sled.

Inaccessible by truck, train, or ship, the site can be reached with heavy equipment by sled in winter. Once the thaw starts, March 15, tractors bog down, wheeled vehicles are useless, the nearby river—lacking bridges—is impassable. With March 15 as the absolute deadline for delivery, Kellogg started a crash program when given the assignment in November.

Avoiding conventional drawings, Kellogg engineered and designed the pilot plant on a scale model, completed it by December 15, shipped it to fabricators in Edmonton as sole reference in building to full size. Meanwhile, as early as November 1, The Canadian Kellogg Company in Toronto had commenced procurement of basic materials and equipment.

By December 15, preliminary fabrication steps were well under way at Edmonton. Auxiliary equipment was beginning to arrive on order from Canadian Kellogg. Necessary subcontracts had been let in Edmonton, and work carefully coordinated.

Before the end of January, the first complete section of the plant had been dispatched to Fort McMurray. By the first week in March, all sections had been sleighed from this railhead to the plant site. To facilitate this last 35-mile trip, each section was designed so that its structural steel could be used as runners.

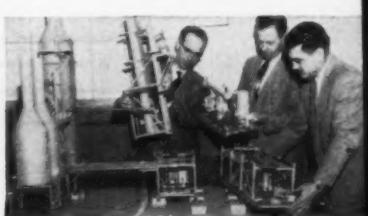
Executives planning additional oil refining units or petrochemical plants are invited to learn more about Kellogg's coordinated engineering-procurement-construction services and how they can speed the completion of new facilities.

THE M. W. KELLOGG COMPANY

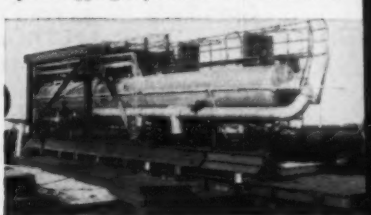
711 Third Avenue, New York 17, N. Y.

A Subsidiary of Pullman Incorporated

Offices of Kellogg subsidiary companies are in Toronto, London, Paris, Buenos Aires, Rio de Janeiro, Caracas



Kellogg engineers in New York examine model of plant, used in building to full size, before shipping to fabricators in Edmonton.



Section of plant loaded on flat car for shipment to Fort McMurray, nearest railhead, and from there for sleighing to the plant site.

Section of plant on way to site. Premature melting of snow in places required dragging of unit on dirt roads. Note integral runners.

Re: The Future for "Liquid Coal"

EARLY LAST YEAR, in February to be exact, the coal mine operators, union leaders, coal-carrying railroads, utilities and coal equipment suppliers banded together to form a new organization—the National Coal Policy Conference. Since that time the activities of this group have made it more and more apparent that the coal industry is united as never before in an all-out effort to recapture the markets it has lost to other fuels—namely petroleum.

Basically, this coal coalition has many specific objectives, but at the present time, one of its main objectives is legislation providing for immediate development of a synthetic fuel (gas and liquid fuels from coal) through coal research.

Historically, it is well known that we have been able to make liquid fuel from coal even before the Drake discovery. As a matter of fact, a memorandum written in 1866 by the Revenue Commission stated:

"Should it (oil production) however come to an end, an ample and permanent supply of oil will be obtained but at higher prices from the shales and rich bituminous coals which are found in almost all parts of the United States and in great abundance."

Hardly Economical. Since that time, many patents for converting coal to oil, gasoline, gas and many other useful products have been issued. None will deny that as a secondary line of defense for our nation's resources, it is indeed encouraging to know that we can fall back on this—if and when it ever becomes necessary. For the time being, however, this process is hardly economical. Like the farm bloc proposal of making motor fuel from grain, it accomplishes no more than can now be accomplished by more economic means—namely by using petroleum, of which there is still ample supply.

This was clearly brought to light during the 1951 hearings of the Senate Interior Committee. In testifying about what private industry has done in the area of synthetic fuels, and why such efforts are not now commercially profitable, Eugene Holman then Jersey Standard president said:

"We studied that problem (developing synthetic fuels from coal) very extensively, senator, over quite a long period of time. We are very much interested in it because in the final analysis I might say that we are the peddlers of liquid energy. We want to live up to the obligation of continuing to deliver liquid energy. The problem is one of finding out which is the best source."

Asked about the progress of coal gasification, Mr. Holman said:

"The Pittsburgh Consolidation Coal Co. and we have worked jointly on the possibilities of that. I am not familiar with all of the details of it but technically there is no question as to what can be done. It is largely a question of economics."

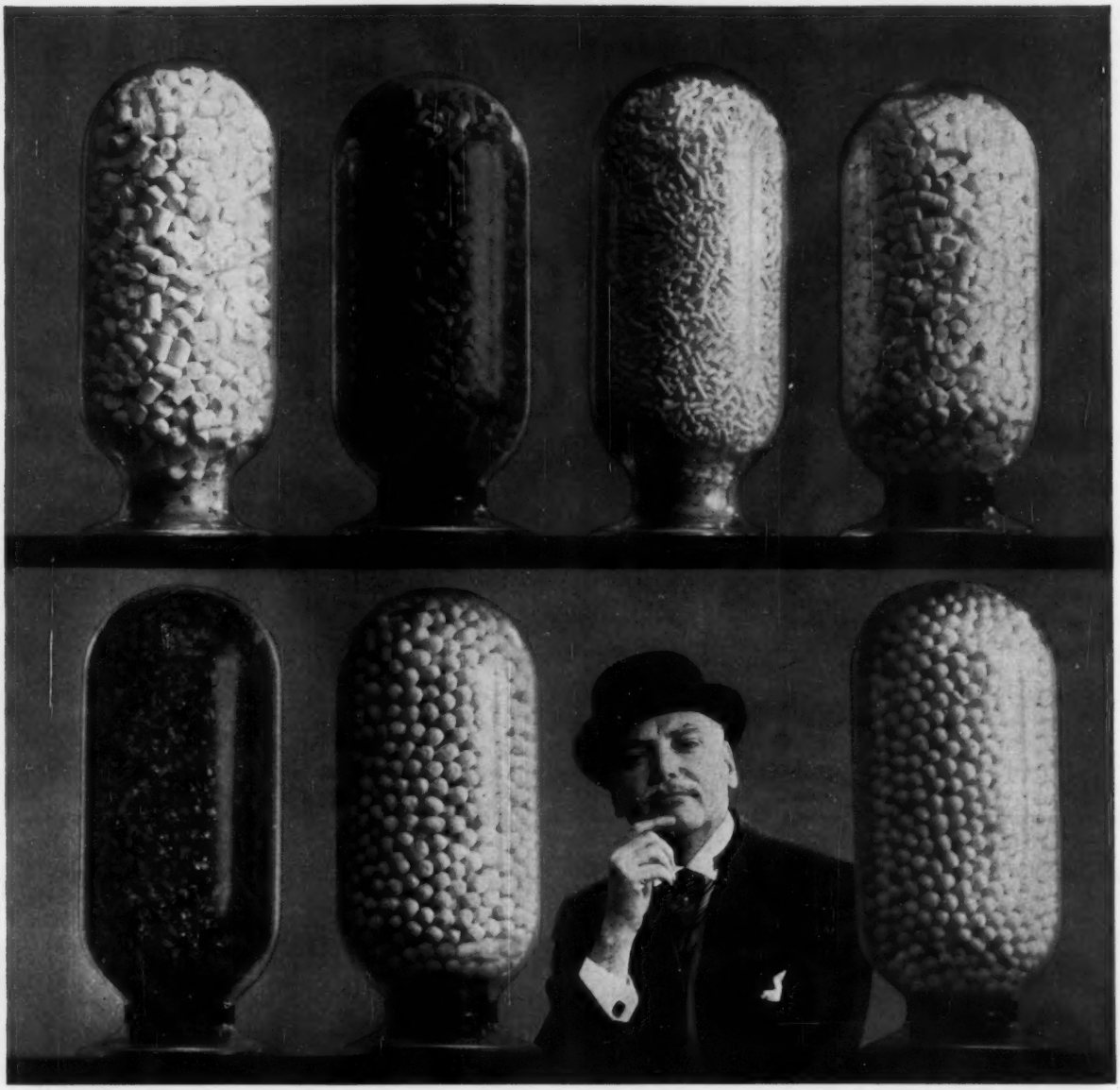
This substantiated the testimony given at an earlier hearing of the same Senate subcommittee. In this instance George A. Lamb, manager of business surveys of Pittsburgh Consolidation Coal Co., said the project was "physically successfully" but commercially unprofitable. He said the Consolidation had to abandon plans to invest $120 million in a plant to produce 30,000 gallons a day when it was found that the cost per gallon for production would run about 20 percent higher than the prevailing price of petroleum-derived products.

Several years later when the question of synthetic fuel development again came before the Senate Interior Committee, a speech of API president Frank Porter was made part of the record. Mr. Porter laid it right on the line by saying:

"Some of the advocates of gasoline from coal claim that this can be done for slightly under 12 cents a gallon before profit and taxes. I say: Why debate it? If the financial backers of such a process feel that it can be done, why not enter their product in this highly competitive market, and let the market answer the question? Apparently, however, many of these schemes envision a government subsidy or markets and prices guaranteed by the United States treasury . . ."

The most recent development in government-financed coal research came last year with the Coal Research and Development Act (H6596) which passed the House of Representatives on June 12. Carrying an appropriation of $2 million for the first year, the bill would create a Coal Research and Development Commission as an independent agency and take coal research out of the hands of the Interior Department's Bureau of Mines.

Never Say Die. This bill passed the Senate on July 27, 1959, but was vetoed by President Eisenhower on September 16 because it would have created an in-



COMPLETE CATALYST SERVICE (BRAINPOWER INCLUDED)

Looking at catalyst samples won't usually show you why one may be better than another of the same general type. Look at plant operating figures, though, and you may see a different story.

That's why getting the right catalyst—for your process, for your plant—usually involves much more than simply buying "off the shelf." Houdry's catalyst service staff has the facts to prove it.

Over and over again, Houdry's process experience has been a major factor in helping processors select the right catalyst, and in helping to get maximum usefulness from it. Process experience is also especially valuable when a custom catalyst must be designed and manufactured.

Houdry's catalyst service is based on more than 30 years of commercial experience in process design and operation and catalyst development and manufacture. This service is Houdry's way of putting "brainpower" into the "package", to help you get the results you want when you select any of Houdry's wide range of catalysts.

It's a good idea to get in touch with Houdry on *any* catalyst problem. There's a good chance that, in solving problems for others, Houdry may have already found the solution for yours.

***HOUDRY**

PROCESS CORPORATION

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*Houdry means Progress...through Catalysis

dependent agency to handle the research program. However, on February 15, 1960 the House again passed and sent to the Senate this same bill.

Another of the objectives announced by coal last year is formulation of a National Fuels Policy involving "end-use" controls of the various forms of energy. The Natinal Fuels Policy Resolution (S. Con. Res. 73) was introduced in the Senate on August 18, 1959 by Senator Randolph (D., W. Va.) along with 42 co-sponsors. In the House, 30 similiar resolutions, all identical, were also introduced. The resolutions call for formulation of a national fuels policy based on ". . . . optimal allocation of the various fuels and energy resources . . ." which presumably means end-use controls.

Within recent months, however, there has appeared in the coal camp some doubt as whether or not this type of governmental control is actually desirable. Oilmen, of course, are firmly against such a policy, and we sincerely hope that in the not too distant future, coal management too will speak out against it. Whether or not they will though remains to be seen.

What's Wrong With Oil?

THE INDEPENDENT Petroleum Association of America has a committee just appointed that has for its object to find out "what is wrong with the oil business." If we said right off that this group is faced with a gigantic task, then some people might draw the conclusion that the problems facing our industry are many, varied and complex. And inasmuch as we would just about have to agree on that conclusion why not then concur in advance that the committee most certainly will need much wisdom and courage plus perhaps a miracle from on high to bring forth helpful suggestions after a very difficult study?

Apparently as they gather in district meetings members of IPAA are being asked to list the troublesome industry areas. Your editor has not attended any of these meetings but he would guess that only slight prodding is needed to get responses. By the middle of last month there had been listed 15 points any one of which would be topic sufficient for hours if not days of comment and debate. Here's the list:

1) Large and increasing surpluses of low-cost foreign oil in the world market.

2) Import limitations under government's mandatory program not tight enough.

3) Excess refining capacity and excessive refinery runs.

4) Failure to adjust all industry operations to a slackening in the rate of increase in oil consumption.

5) Pipe line proration, failure to make pipe line connections, enforced trucking charges and other purchasing practices.

6) Excess output (in states that do not limit production to market demand).

7) Expansion of total U.S. producing capacity over and above increases in demand.

8) Excessive development drilling.

9) Inadequate research to reduce finding, development and production costs.

10) Uneconomic refinery prices resulting from income import allocations.

11) Loss of oil markets to low-price natural gas.

12) Uncertainty, increased costs and other depressing effects of FPC regulation of gas production.

13) Lack of the leadership and industrial statesmanship that should be exerted by industry leaders.

14) Unsound actions growing out of misunderstanding between segments and groups within the industry.

15) Inconsistency in some policies and action by government as to oil and gas.

As Minor S. Jameson, Jr., IPAA executive vice president commented, these 15 points indicate the scope of work facing the new committee. And the difficulties, we might repeat.

So as the wheel starts turning, we join with IPAA members in hoping that the members of this study group are endowed not only with omniscence but much patience, plenty of tact and transcending courage. It will take all of these endowments plus others perhaps to produce worthwhile findings on all the counts. If they succeed on just a few of them then the effort could be termed quite successful.

Want to Keep Up?

WE THOUGHT the fast moving technology hadn't passed up at least one part in our basic education—the multiplication tables we learned in grammar school. However, the National Bureau of Standards has joined the International Committee on Weights and Measures in using new prefixes for denoting multiples and sub-multiples of units.

With this new table, we can say that gasoline production in 1959 hit a new peak of 1.49 gigabarrels, although it's too early to say if this figure is accurate to the last nanobarrel.

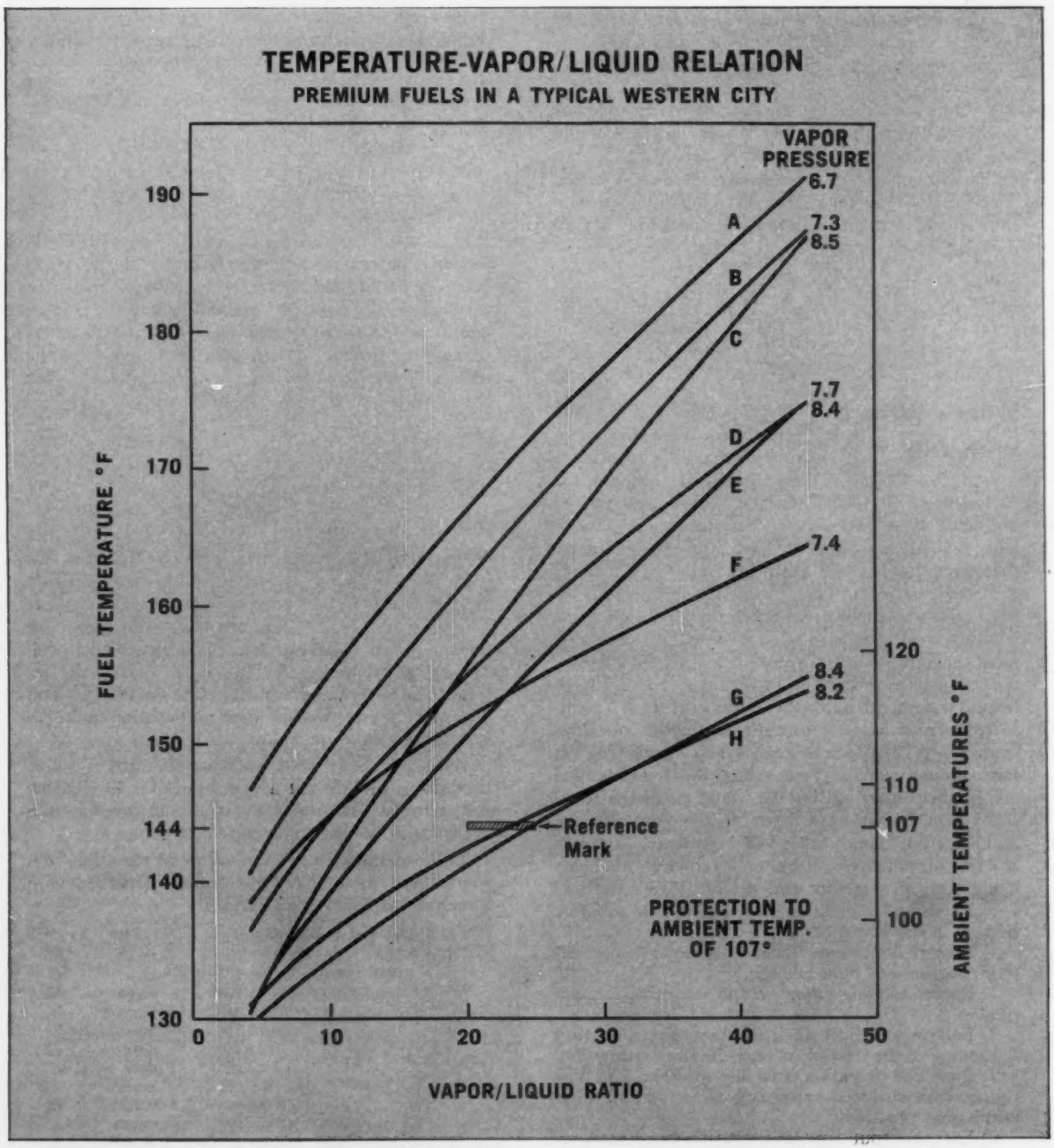
To keep up with the new crop of scientists, you should add these four new prefixes (marked with asterisks) to your vocabulary:

Multiples and Sub-Multiples	Prefixes	Symbols
1 000 000 000 000 = 10^{12}	tera*	T
1 000 000 000 = 10^{9}	giga*	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10	deka	dk
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano*	n
0.000 000 000 001 = 10^{-12}	pico*	p

Here's a practical method for analyzing Front-End Volatility

Ethyl Research uses temperature-vapor liquid ratio curves to study relative and absolute front-end characteristics of gasoline

by **GILBERT WAY** — *Research Representative*



The above curves were calculated by the CRC method using Ethyl Volatility Survey data.

For more data on advertised products, use Readers' Service Cards, last page.

WHERE TO SET front-end volatility for optimum balance of economic and automotive benefits is an important question for refiners.

One result of Ethyl's work in this field is a routine approach to interpretation and comparison of seasonal volatility data. The method can be used to establish or review volatility requirements at both the refinery and marketing levels. Data from the Ethyl Volatility Survey are used as the basis for temperature-V/L studies. *Refiners may have analyses of their own marketing areas upon request!*

Method is Simple; Easy to Understand

Temperature-V/L ratio curves—widely accepted as a graphic representation of how gasoline vaporizes in a fuel system—are used to show the volumes of vapor formed per volume of liquid at any given gasoline temperature. (Curves were calculated by the CRC method.)

In addition to showing relative vaporizing tendencies among various fuels, the curves may be related to reference points that indicate average conditions of fuel temperature and limiting V/L in automotive fuel systems. In the accompanying graph, average conditions for premium fuels are shown by the reference mark ranging from 20 to 25 V/L at a fuel temperature of 144°F.

This reference mark range was established from the results of extensive road tests conducted in recent years. Many factors were considered in arriving at this practical bench mark, such as severity of test conditions, age and condition of fuel system components, and variation of individual cars from average characteristics.

In theory, a fuel having a curve which passes through the reference mark would represent highest desirable use of front-end "fill." Those above the mark would be more conservative and those below subject to vapor lock.

The estimate of fuel temperature was established by adding the temperature rise at the fuel pump under severe vapor locking conditions and the ambient temperature to which protection against vapor lock is desired. Experience has shown that this fuel temperature rise at the pump averages 37°F. In the marketing area represented in the graph, protection is desired up to 107°F.

Some Interesting Observations on Volatility

The figure shows a wide variation in vaporizing tendency of fuels. Fuels A, B and C indicate a conservative position. This is contrasted by high volatility and border line protection against vapor lock by curves of fuels G and H.

Curves having steep slopes are typical of fuels pressurized by butane. Those with flat slopes indicate a high pentane content. Fuels C, E and G have essentially the same Rvp of 8.4 to 8.5. They converge at a V/L of 4, the V/L of the Reid vapor pressure bomb.

A V/L of 25, however, is reached by fuel G at a fuel temperature of 144°F., whereas fuel C must reach 163°F. before evolving the same quantity of vapor. Thus fuel C offers more protection against vapor lock than fuel G when abnormally high temperatures are encountered. This illustrates that, *for a given Rvp, butanized* fuels offer greater vapor lock protection in motor vehicles than fuels that are pressurized largely by pentane. Another way of comparing these two fuels is at constant temperature: at 150°F., fuel G has 35 V/L, fuel C only 16.

How Ethyl Research can help you

In addition to participating in Oil Industry cooperative studies, Ethyl Research has worked with many individual oil companies in studies of vapor locking tendencies of fuels and engines.

The experience gained in these programs provides a broad understanding of the problems associated with front-end volatility.

Our engineers are prepared to bring you analyses of Temperature-V/L characteristics of fuels from marketing areas of your choice.

If you would like this service, or more information about it, just call your Ethyl Representative. He'll be glad to make the arrangements.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

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How lasting quality is Heat Exchanger

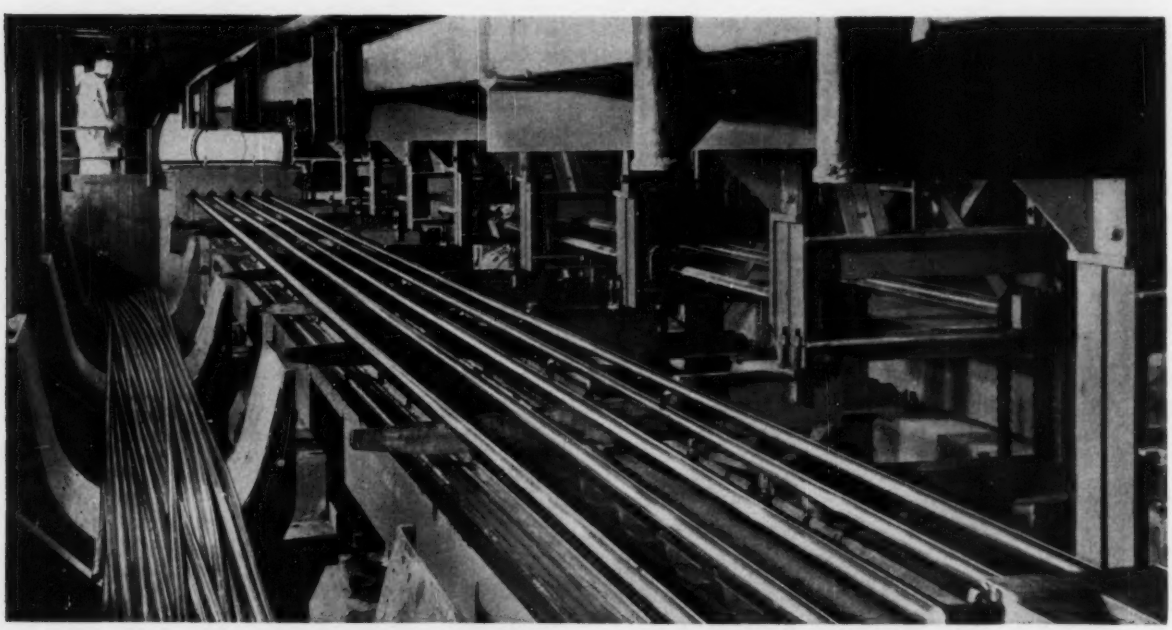
Drawing is a basic tube fabrication operation that transforms newly extruded tubes into standard and special size tubes for various applications. Phelps Dodge uses the cold-drawing process, a method in which precise control and master craftsmanship are combined to produce tubes that meet the most exacting specifications.

The cold-drawing method is used throughout, because it assures maximum tube quality through carefully coordinated operations on a drawbench where simple axial tension is applied.

After initial lubrication the tubes are brought to the drawbench. Each tube is slipped over a mandrel and hollow supporting rod, then drawn through a die and over the mandrel to form a tube of the desired diameter and wall thickness. Continuous lubrication is applied to each tube during this operation to control surface quality and minimize heat generated during the processing cycle.

Dual-gauge tubing is the result of a modified drawing operation which was developed by Phelps Dodge. In this operation, a heavier wall thickness is provided at one or more points of the tube length to compensate for thinning of the outer portions of return bends. In this manner, uniform thickness is retained where ordinary tubes thin out.

Throughout the entire tube fabricating operation—from raw materials to finished product—quality is the keynote. That's why Phelps Dodge tubes are preferred by those who demand the finest . . . the manufacturers and users of heat exchangers and condensers.

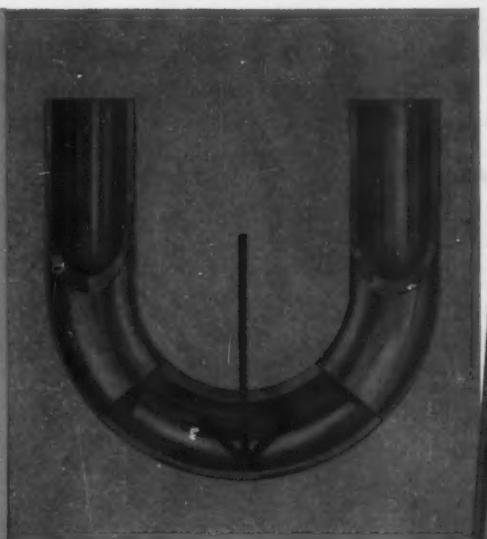


In automated drawing operation at new Phelps Dodge mill, tubes are pulled through reducing dies into smaller diameters and longer lengths.

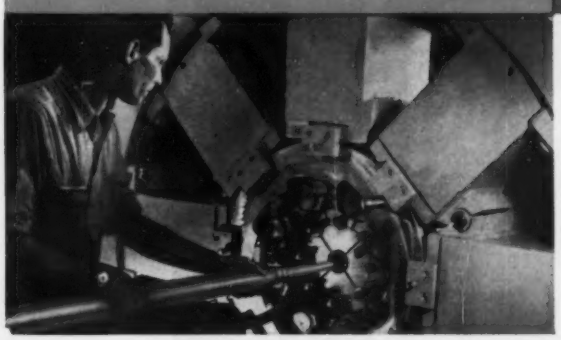
built into Phelps Dodge and Condenser Tubes...

3 DRAWING

(THIRD OF A FIVE-PART SERIES)



Cutaway of Dual-gauge tube; note how extra metal provides additional safety factor by retaining uniform wall thickness at return bend.



Pointing one end of an extended copper shell, a preliminary step in the drawing process.

PHELPS DODGE COPPER PRODUCTS CORPORATION

First for Lasting Quality—from Mine to Market!

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Chromate disposal problems? Dearborn's NEW 860 ends them

Does your chromate-containing cooling water treatment give you waste disposal problems?

Have you lived with these problems because you believe chromates give you better results?

Quite likely, your answers are yes. We have a more satisfactory answer—new Dearborn 860 with Endcor-B.

Dearborn 860 is a non-chromate cooling water treatment incorporating Endcor-B which bolsters protective films...minimizes sludge deposits.

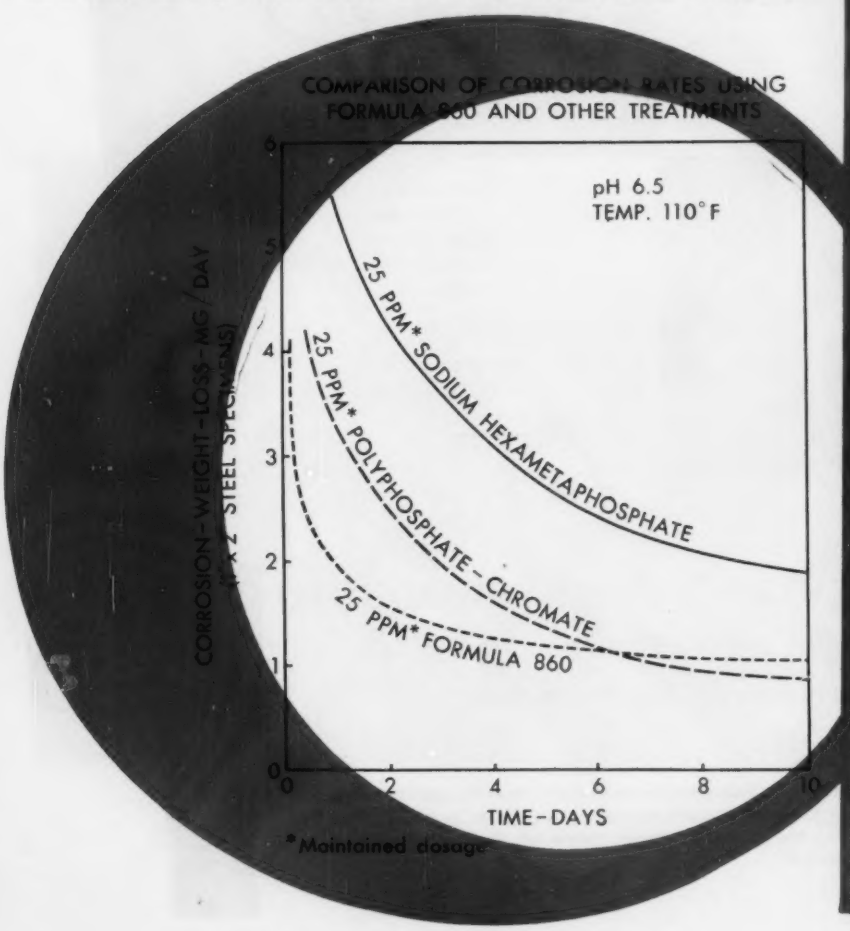
Check these outstanding advantages...

- Results comparable to chromate-containing treatments.
- Non-toxic. No waste disposal problems.
- Extremely rapid film formation. Important in new plants or immediately after shut-downs or turn-arounds.
- Economical to use. Easy to feed.

A Dearborn engineer will be glad to demonstrate the effectiveness of 860 for your plant. Call him today or write for detailed Technical Bulletins.

DEARBORN CHEMICAL COMPANY

General Offices: Merchandise Mart, Chicago 54 • Dallas • Des Plaines, Ill. • Ft. Wayne • Honolulu Linden, N. J. • Los Angeles • Nashville • Omaha • Pittsburgh • Toronto • Havana • Buenos Aires



pioneer in the science of corrosion control

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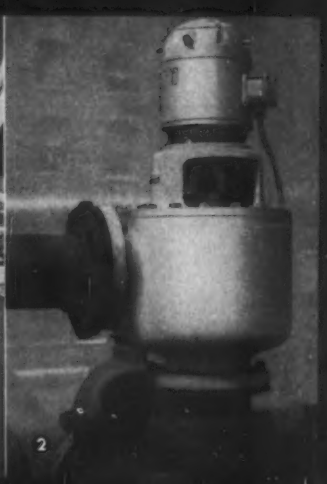
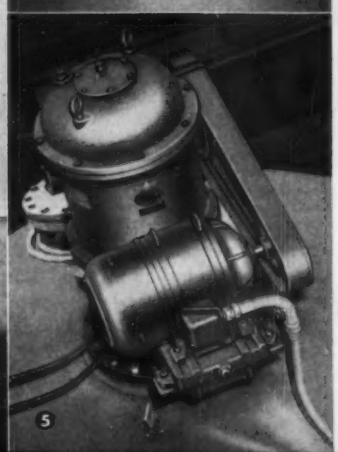


Improved Processing through Engineered Agitation



HOW IMPORTANT IS GOOD FLUID MIXING IN YOUR PROCESS?

REGARDLESS OF HOW SPECIALIZED your particular processing needs are, good mixing can be the difference between "run of the mill" and maximum yields.

NETTCO MIXERS ARE PROCESS-RATED for optimum performance. Your particular process requirement is fully evaluated. And—it costs no more to get the full benefit of Nettco's wealth of agitation technology and broad application experience. Then—from design and pilot test to full process conditions, standard components are precision teamed to provide you with a Nettco mixer to meet your most exacting conditions. If good fluid mixing is vital to your process, then Nettco Engineered Agitation is vital to *you!*

PUT NETTCO ENGINEERED AGITATION TO WORK FOR YOU. From a full line . . . side drive, tank top, portable or tripod and unique continuous pipeline mixers, NETTCO can provide the answers to a wide range of mixing problems. See your NETTCO representative listed in Chemical Engineering Catalog or Refinery Catalog, or write for Bulletin 581, NETTCO CORPORATION, 81 Tileston Street, Everett 49, Mass.

NETTCO

ENGINEERED AGITATION SPECIALISTS

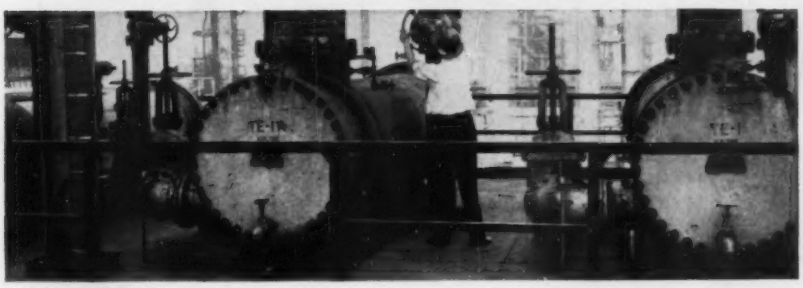
EVERETT 49, MASSACHUSETTS

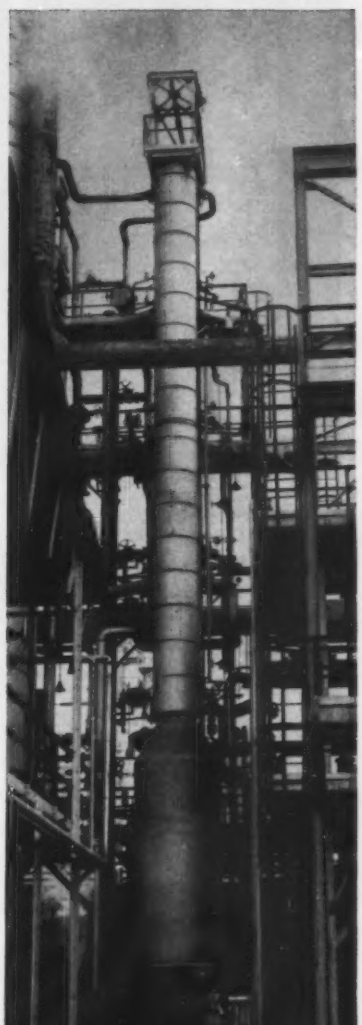
1. Paint blending with Nettco tank top mixers on 400 gallon portable tanks.
2. Nettco Flomix® in the continuous recycling of waste product to improve yield.
3. Variable speed pilot plant application of Nettco medium speed, propeller drive mixer.
4. Raw material batch blending with Nettco side drive mixer to assure uniformity.
5. 15 year old Nettco tank top mixer for synthetic rubber production with one of first double mechanical seals.

Notable performance —This crude unit at the Mobil Oil Company Refinery, Paulsboro, N. J., has served without maintenance of the Monel-clad tower and exchanger shells since December 1949. Monel-Clad Steel amounting to 20% of the plate thickness (7/64-inch on a 1/2-inch vessel wall) was used in the top portion of the atmospheric crude tower which operates in the 200-300°F range. The 16-foot high clad section has an internal diameter of 12′ 5″. Monel alloy exhibits outstanding resistance to both general and local corrosion under the conditions encountered.

HCl and H_2S corrosion of refining equipment

Monel* nickel-copper alloy shows outstanding resistance to both general and local corrosion in the upper portion of distillation columns, and in reflux and overhead systems where the lower temperatures and the presence of steam favor existence of an aqueous phase, or "fog area," containing hydrochloric acid, hydrogen sulfide and — possibly — carbonic acid. Neutralization with ammonia and injection of an organic inhibitor has reduced corrosion of steel piping as much as 90%. But unprotected steel has still corroded 0.01 i.p.y. or more. Monel alloy has suffered no measurable loss.





Low overhead—Monel-clad steel shells have also been used for the five smoothly functioning overhead exchangers at Paulsboro. These units operate at temperatures ranging from 100-200°F. The shells have internal diameters of 3′ 3″ and are 16′ long. In addition to its excellent corrosion resistance, Monel alloy provides three big additional advantages: 1) Ease of fabrication, 2) Good welding characteristics, and 3) ready availability, often directly from the warehouse stocks of distributors conveniently located throughout the country.

Dual personality—Two-compartment gas-water separator system at Paulsboro is also Monel-clad steel. One compartment operates at about 170°F. The other at 100°F. Internal diameter of separator is 6′ 6″. Its height 20′. To resist corrosion by dilute mineral acids, Monel alloy is also used for partial linings in reflux and distillate accumulators, reflux pump components, valves, valve trim. For help on metal problems, feel free to call Huntington Alloy Products Division, The International Nickel Company, Inc., 67 Wall Street, N.Y.5, N.Y.

New Companion Material to Monel Alloy.

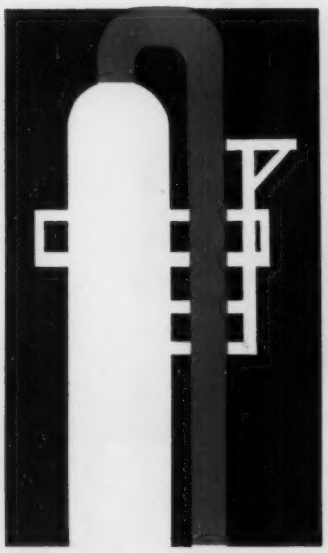
Ni-o-Nel* nickel-chromium-molybdenum alloy is a new commercial alloy available for normal delivery. Its physical and metallurgical properties and its resistance to corrosion are discussed in detail in our recently published Technical Bulletin, "Engineering Properties of Ni-o-Nel." Write for a copy. Just ask for Bulletin T-37.

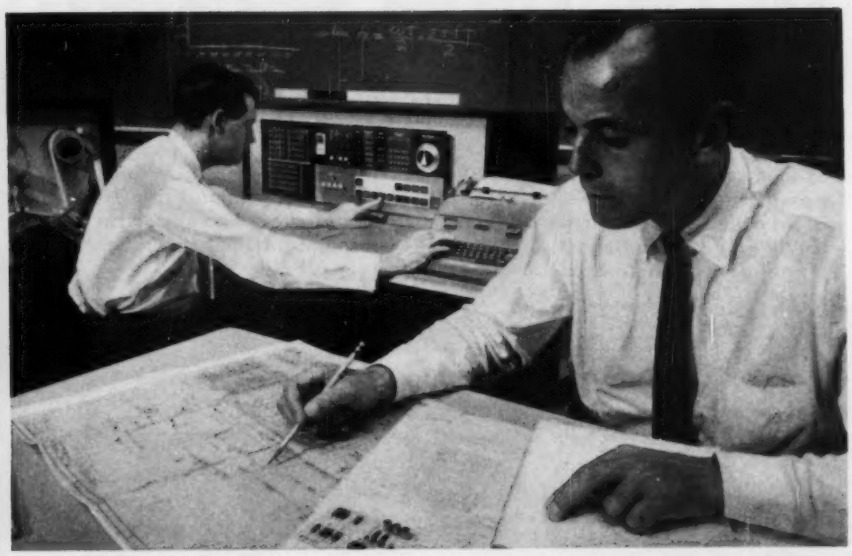
*Inco trademark

MONEL®

IBM 1620 *data processing system*

...the most powerful engineering computer in its low price class





In the Petroleum Industry the IBM 1620 solves problems like these:

- *evaluation of refinery blending options*
- *oil transmission and product inventory data for pipe line supervision*
- *geological interpretation of seismic data*
- *design calculations*

The new IBM 1620 is a desk-size engineering computer that offers you more computing ability per dollar than any system in its price class.

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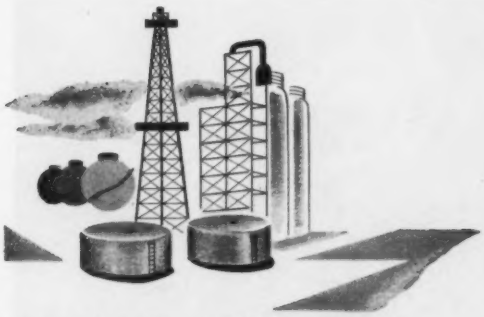
Ask your IBM representative about the unique advantages of the IBM 1620. Like all IBM equipment, it may be purchased or leased.

IBM ® *balanced data processing*



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STOP WEEDS

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SIMAZINE *or* ATRAZINE

pre-emergence *pre- or post-emergence*

HERBICIDES

Economical, long residual Geigy herbicides save time and money—do the job right the first time. One application stops weeds before they start—gives you season long control.

Safe to humans and animals, non-irritating to skin, non-flammable, non-corrosive to equipment. Safe to use on valuable land. Available through leading distributors.

FREE BROCHURE: *New full color booklet contains complete directions, diagrams, applications and other useful data for both Simazine and Atrazine.*

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Send free weed control brochure to:

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Geigy ORIGINATORS OF DDT INSECTICIDES

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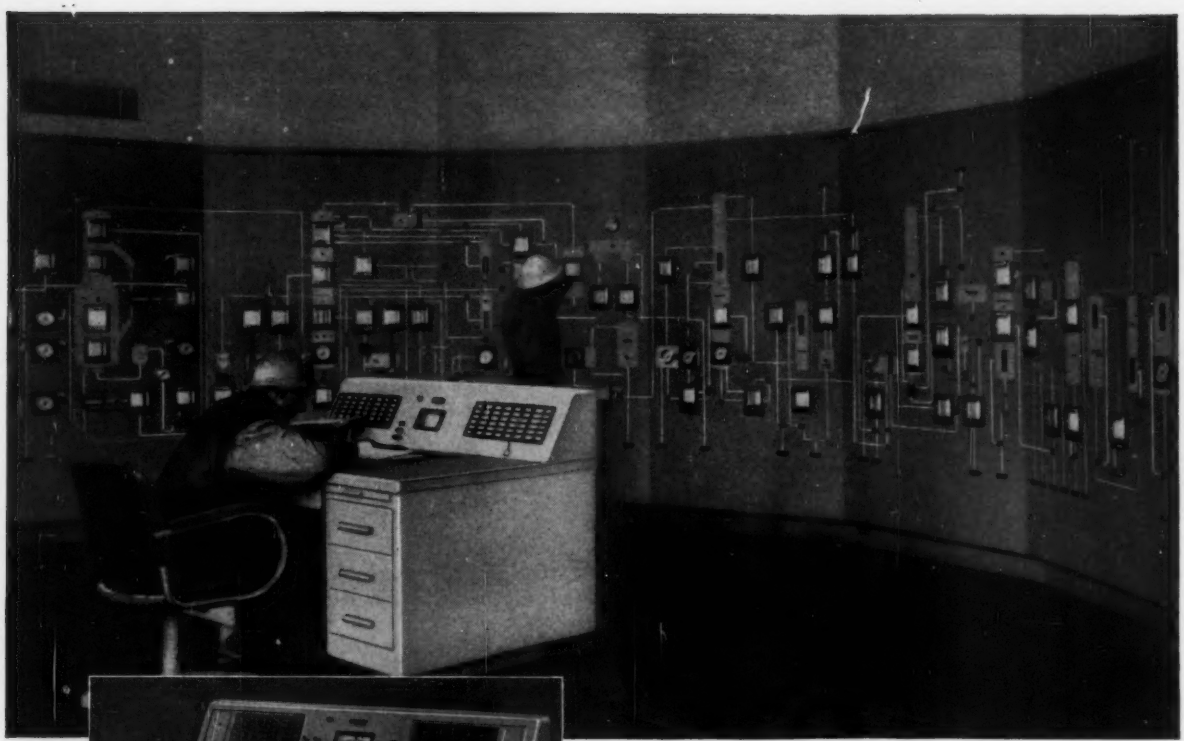

Read up to 288 temperatures at this Honeywell "Operator's Desk"

This compact console type Operator's Desk makes it possible, from one central location, to read as many as 288 thermocouple points, or 192 points with identifying card holders. Its *ElectroniK* Precision Indicator and switch assemblies are mounted for ease of reading whether the operator is sitting or standing.

The *ElectroniK* Precision Indicator, accurate to 1/5 of 1% of full scale, can be of single range, double range or extended range type. Use it with all types of thermocouples, millivolt actuation, or a combination of the two. The desk can be supplied with a telephone dial system for thermocouple selection, rather than key or pushbutton switches. Additional equipment such as lights and clocks can be built in.

Servicing is simplified. Instrument and switch terminal blocks are in the lower rear portion of the desk, readily accessible from the back of the console. All wiring enters from the bottom of this compartment.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

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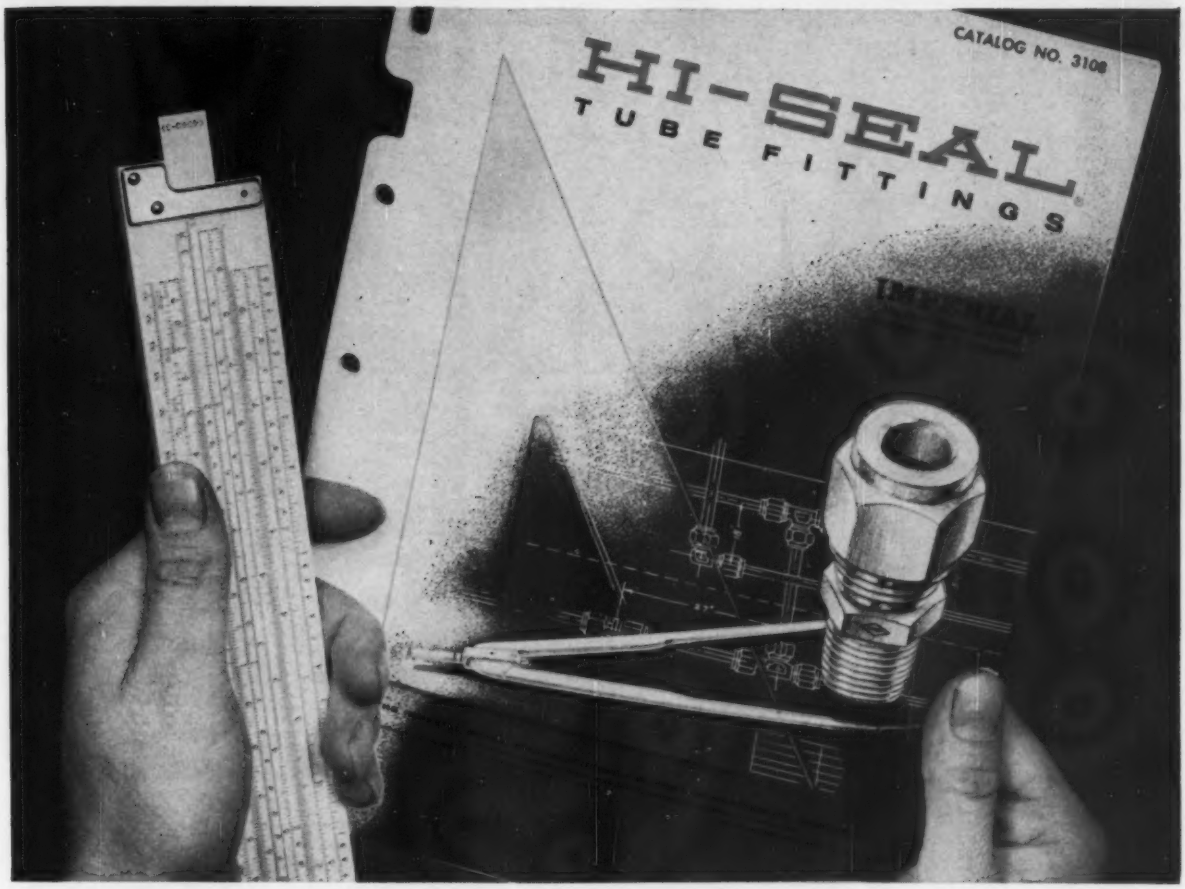

Your slide rule or this New Hi-Seal Tube Fitting Catalog...

YOU'LL WONDER WHICH ONE HELPS YOU MOST!

Just off the press! A working handbook for every man concerned with tubing and fitting circuitry. Published by the company with a habit of leadership.

Leading hydraulic and pneumatic engineers, when asked to study advance proof copies of Imperial's new Hi-Seal Catalog, came back with comments like these: "It's a reference manual" . . . "The kind of material I've had to dig up for myself, until now, from several reference sources" . . . "Make sure I'm on your list for a copy as soon as they are available."

The new Imperial Catalog of Hi-Seal tube fittings contains data, charts, laboratory tests, and formulae on corrosion, vibration, temperature, pressure and vacuum, flow and velocity — vital statistics in hydraulic and pneumatic tubing circuitry design. And it describes the complete line of Imperial Hi-Seal Tube Fittings — *industry's most complete line,* based on a single-design concept, that meets all tubing circuitry requirements. All items in this catalog are stock items and are priced as stock items.

Write for Catalog No. 3108

THE IMPERIAL BRASS MANUFACTURING CO.
Dept. PR-30, 6300 West Howard Street, Chicago 48, Ill.
In Canada: 18 Hook Avenue, Toronto, Ontario

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Since 1957, when seven Selas Gradiation® heaters went on-stream, Phillips Chemical Company's, Sweeny, Texas, plant has had to increase production capacity *twice*, to meet the continuing booming demand for high-quality ethylene. On both occasions, this leading producer of petrochemicals has turned to Selas to help meet additional requirements.

Selas Gradiation tubular heaters deliver:

- Preciseness of Heating . . complete combustion within Duradiant® burner cup permits placing burners close to tubes . . achieving fast heat-up, instantaneous response to controller demand.
- Heat Uniformity . . even distribution of heat, along and around tubes, increases tube life by eliminating hot spots, minimizing coke formation.
- Versatility . . Duradiant burners, readily adjustable to desired heat pattern, provide Zone Control which enables meeting any time-temperature curve in pyrolysis or catalytic reactions.
- High conversion and selectivity plus ability to process butane and propane feed stocks, interchangeably.
- On-stream periods, without shutdown, well in excess of 30 days.

May we arrange for a Selas field engineer to discuss your heat processing needs with you? For this service—without cost or obligation to you —or for a copy of Bulletin "Gradiation Heating for Petroleum and Chemical Processing" write to Mr. M. R. Kitzen, chief process engineer, Fluid Processing Div., Selas Corporation of America, 73 Dreshertown Road, Dresher, Pa.

Gradiation and Duradiant are registered tradenames of Selas Corporation of America.

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HEAT AND FLUID PROCESSING ENGINEERS development · design · construction

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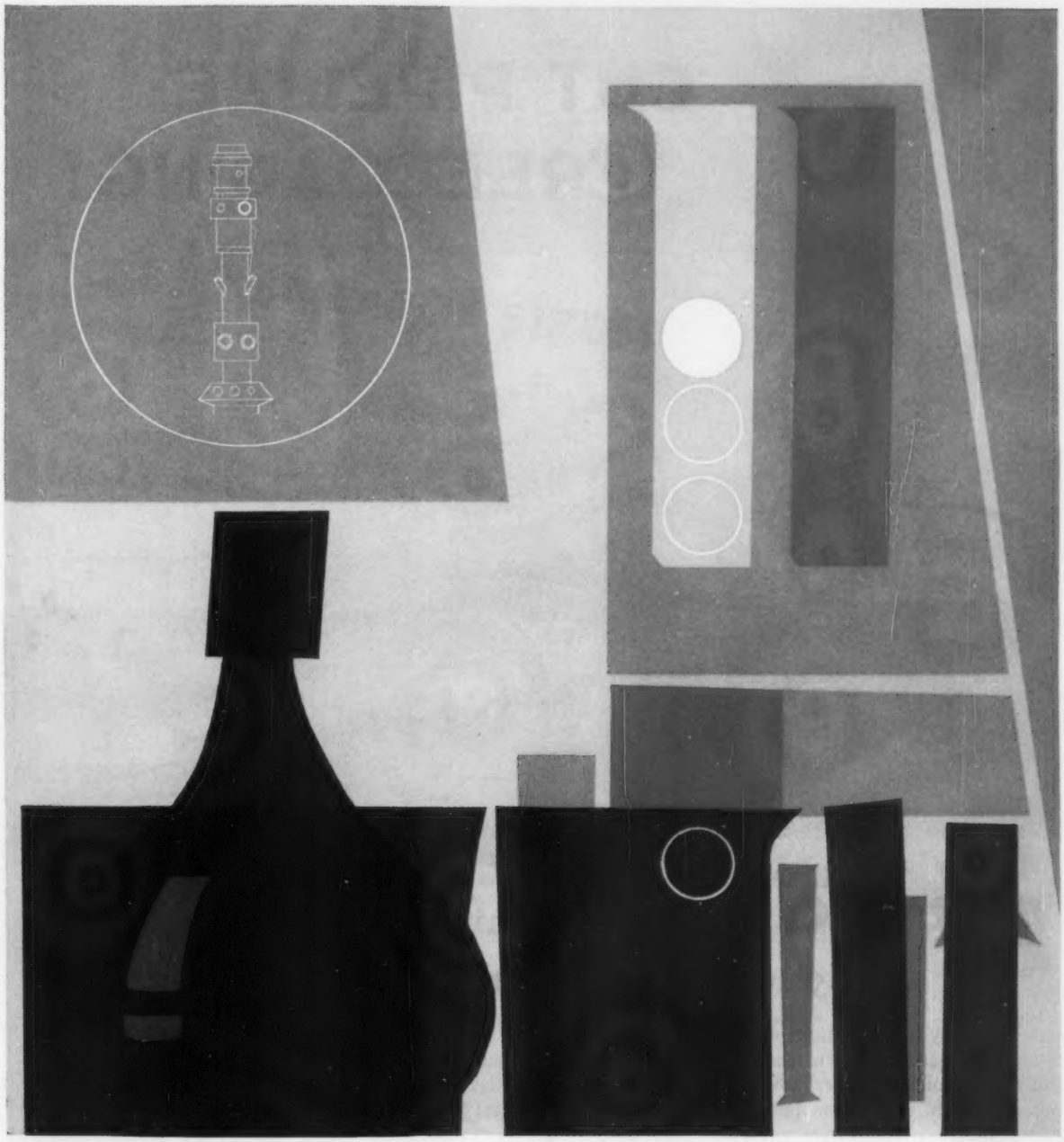

Constant search and research by Alcoa makes it pay to

mix imagination with Alcoa Aluminas

Out in East St. Louis stands the birthplace of new products and product improvements affecting nearly every American industry. There, you'll find ALCOA operates the only fully equipped laboratory facility devoted to the constant development of new forms, grades and uses for alumina, one of nature's most versatile materials. There, ALCOA has developed the variety of types and grades of alumina that have made possible—or made better—products ranging from tooth paste to missile nose cones. There, exist the facilities and the man power able to adapt the outstanding chemical, mechanical, thermal and electrical properties of alumina to your needs. Why not let us tackle *your* problem? Simply describe it in a letter to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 708-C Alcoa Building, Pittsburgh 19, Pennsylvania.

For finer products, let Alcoa add new dimension to your creative thinking!

ALCOA CHEMICALS

For exciting drama, watch "Alcoa Theatre," alternate Mondays, NBC-TV, and "Alcoa Presents," every Tuesday, ABC-TV

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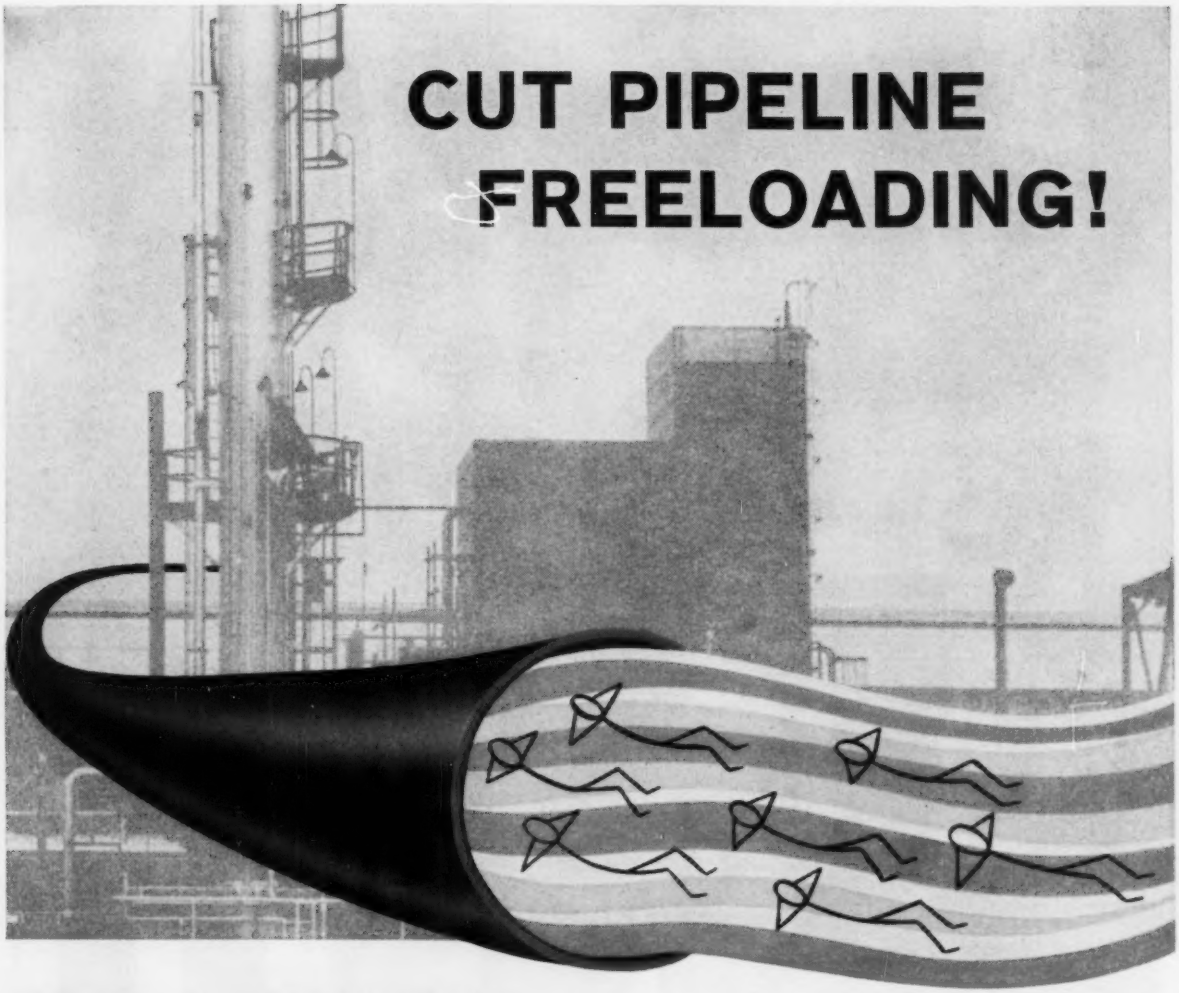

AIR LIQUIDE eliminates "dead head" gas by low-temperature separation

Here's the way to rid pipelines of unwanted nitrogen, upgrade natural gas and make profits on superfluous yet valuable gases. *Install an American Air Liquide low-temperature gas separation plant*, economical to operate and requiring minimum of attention.

Many natural gas pipelines are carrying "dead head" nitrogen that builds up compression, increases transmission costs and reduces pipeline payload. This nitrogen is removed — at pipeline pressure — by the American Air Liquide process.

At the same time that your natural gas is upgraded, unwanted gases are removed — yielding further profit instead of going to waste as inerts, flue gases or engine exhausts along with a loss of valuable heat. To quote only one example, the extraction of helium offers considerable direct profit from this efficient, economical process.

For further information on our complete low-temperature service — from process engineering of complete plants and custom-designed equipment to technical consultation and plant erection — write or call us: Chrysler Building, 405 Lexington Ave., New York 17, N.Y.

PROFITABLE ADVANTAGES OF NITROGEN REMOVAL

1. Raises calorific value — more BTU's per pipeline.
2. Simultaneously removes heavier hydrocarbons for separate sale.
3. Enables compressors and pipelines to handle capacity payloads.
4. Improves flow characteristics: reduces density and viscosity; reduces pressure drops.
5. Cuts compressor fuel costs.
6. Produces helium simultaneously from helium-bearing gases.

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10 TO 3000 GPM CAPACITIES!

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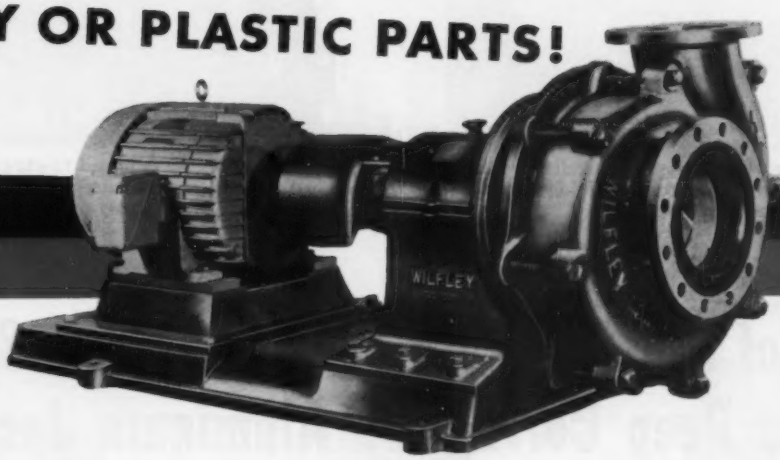

Whatever your pumping job requires, there is a Wilfley Acid Pump to handle it—dependably, economically. Wilfley's simplified packingless design and rugged construction guarantee trouble-free operation, higher output, longer pump life. *And, to give you maximum pumping economy, every Wilfley installation is* JOB ENGINEERED.

Pumping parts are available in a variety of metal alloys, as well as plastic, to cover a wide range of corrosive applications.

Write, wire or phone for complete details.

Wilfley Sand Pumps
"Companions in Economical Operation"
Wilfley Acid Pumps

A. R. WILFLEY and SONS, Inc.

Denver, Colorado, U.S.A. • New York Office: 122 East 42nd Street, New York City 17

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Permanent protection for costly insulation on fractionators and caustic washers at Phillips Petroleum Co. refinery at Sweeny, Texas, is provided by New Childers Deep Corrugated Jacketing with factory-attached moisture barrier.

Protection for the costly insulation on this caustic washer was applied in one easy operation because Childers Jacketing has factory-attached moisture barrier.

These gleaming aluminum-covered towers will always look new! No need to paint Childers Jacketing . . . a savings that alone may pay full cost of jacketing *plus* installation!

Why 724 plants specified this . . .

New Kind of Protection for Towers, Vessels & Tanks ...Childers Deep Corrugated Aluminum Jacketing:

Read why exclusive benefits of factory-attached moisture barrier are fast making Childers Jacketing the standard of the industry.

Only Childers gives you this special feature: Factory-Attached Moisture Barrier that (1) eliminates any danger of harm to the underneath side of the jacketing. And, (2) saves you time, labor and money because you apply jacketing with moisture barrier already attached . . . in one single operation.

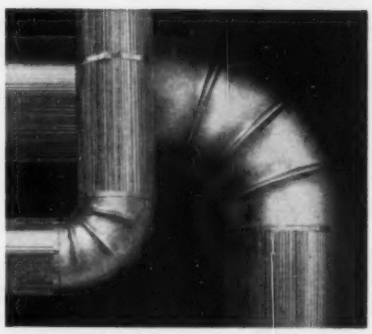
You also get greater strength and greater protection at less cost with Childers Cross-Crimp®. Tests prove the rolled-in 3/16" cross corrugation increases the vertical strength and rigidity of .019" thick aluminum to that of plain .032" thick aluminum. Jacketing costs are consequently reduced as much as ⅓ when Childers Jacketing is used instead of ordinary sheet aluminum.

It's easy to install Childers Deep Corrugated Jacketing. Jacketing is applied with sheet metal screws used on both the vertical and circumferential lap. Screws may be omitted from circumferential lap when necessary to provide expansion joints.

Comes in two corrugations: 1¼" and 2½"; and four thicknesses: .016", .019", .020" and .024". The .019" and .024" thicknesses are made from roofing alloy for maximum life—recommended for normal jacketing of towers, vessels, and tanks. The .016" and .020" thicknesses are available in #3003-H-14 alloy.

For a free sample of Childers Deep Corrugated Aluminum Jacketing with factory-attached moisture barrier, plus engineering data on how to safeguard your insulation, write to Childers Manufacturing Company, Dept. PR-47, P.O. Box 7467, Houston 8, Texas.

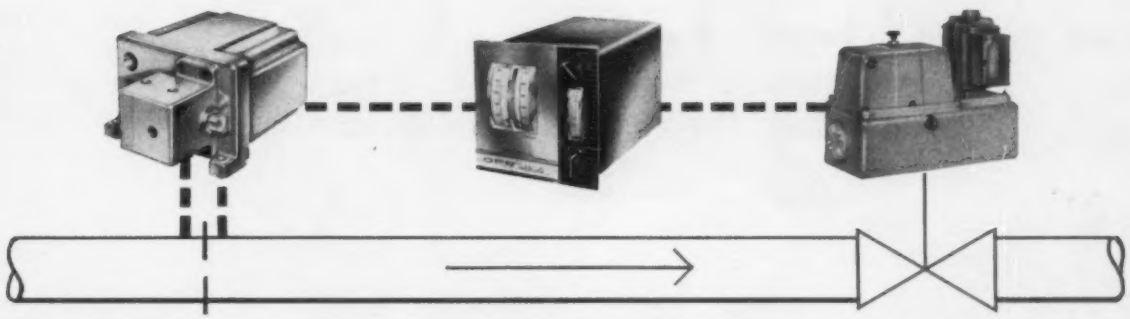
In Canada, write direct to Peerless Mfg. Co., Sub-Post Office 28, Calgary, Alberta.



For insulated lines Childers Aluminum Weather-Proof Jacketing in rolls goes on about 30% faster than ordinary weatherproofing, fits perfectly, never needs painting. Used with Childers exclusive 90° and 45° Ell-Jacs, this modern aluminum protection gives your insulated lines that well-dressed look from end to end.

Only Childers makes available to you complete specifications and engineering data on aluminum jacketing in these catalogs: Refinery Catalog pp. 375-378; Sweet's Industrial Construction File pp. 6b/Ch; Chemical Engineering Catalog. pp. 945-948.

Electronic Flow Control System built by **GPE Controls** brings you the highest possible degree of dynamic accuracy. Three times as fast as other systems. Outstandingly reliable. Adaptable to nearly all flow control jobs. Ready for you now at surprisingly **low cost.** Easy, inexpensive installation: Simple unshielded wiring, no air compressors, no separate hydraulic pumps, no tubing connections. Low maintenance; unequalled performance.



776F Flow Transmitter

Lowest differential pressure requirement of any transmitter – as low as 3" w.c. for maximum output of 25 volts d.c. at power levels up to 5 watts. Permits use of larger orifices; transmission over greater distances with simple unshielded wiring; simultaneous operation of controllers, recorders, etc. Automatic square root extraction for straight summarization of flows, highest accuracy at large turndowns. Fully transistorized . . . no vacuum tubes.

R462 Flow Indicating Controller

Complete linear indication of both set point and process – not just an error indication. Set point and process scales are parallel, for fast visual comparison. Manual/automatic control. Valve position indicator is optional. Outstandingly simple in design and construction. No vacuum tubes, no transistors. Compact panel-mounting, easy installation.

687 Electro-Hydraulic Valve Actuator

The simplest, lowest-cost way to operate a control valve from an electric signal. This model positions 4" double-seated valve at 1000 p.s.i. pressure drop. Completely self-contained. Feedback through process for true integral control . . . proved most reliable in more than 10,000 installations with up to 30 years operating experience. Automatic locking with power failure simplifies start-up of process.

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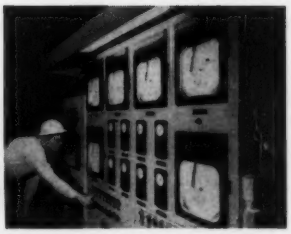

These Bristol Instruments at Lithium Corporation of America, Bessemer City, N. C., are part of an extensive installation that keeps tabs on such variables as temperature, pressure, absolute pressure, flow, liquid level, and pH.

Almost every industry can benefit from BRISTOL INSTRUMENTATION

Here's an outstanding example of the way Bristol is helping thousands of industrial processes today:

In Lithium Corporation of America's plant for extraction of vital lithium compounds, located in Bessemer City, North Carolina, near this nation's largest ore deposits, precision Bristol instruments monitor and control practically every step of the extraction process.

From the early planning stages, Bristol instrument engineers worked closely with Lithium Corporation engineers in designing the instrument system for this modern plant. Temperature, pressure, absolute pressure or vacuum, flow, liquid level, and pH had to be recorded or controlled at a multitude of points in the complex extraction process. The Bristol instruments used included electronic Dynamaster* potentiometers and pyrometers, pneumatic and time program controllers. In operation for nearly four years now, the Bristol instruments have been doing a precise job of recording and controlling despite vibration and a corrosive, dusty environment.

This is just one example of the way Bristol can work with you in selecting the *right* instruments for your process. Bristol makes the most complete line on the market of full-size and miniature instruments for measurement, recording, automatic control and telemetering of almost every industrial variable. And Bristol Application Engineers are always ready to advise and assist you in applying them to your process. Write: The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.

*T.M. Reg. U.S. Pat. Off. B-48

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

How Foster Wheeler gives you "profits" from chemicals you don't make

It's a matter of getting full value out of ideas . . . because ideas that start with one chemical product or process can often make another *different* product or process better, or more profitable.

Today, for instance, one producer of *methanol* is enjoying benefits of "profit ideas" based on FW's experience in combining methanol and ammonia synthesis. Another example, FW's design for production of high quality phthalic anhydride makes possible new profit-making efficiency for plants with capacities of three tons per day or more.

Find out about these and many other "profit ideas" FW can offer, by writing to Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N.Y. Ask for the new booklet about "The Plant You Want to Build".

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take NEWTHERM on test!

Test its STRENGTH

NEWTHERM is unusually strong and rigid—a feature of special importance in the larger, more vulnerable sections. Put a sample section or slab on part of your plant and *prove for yourself* its outstanding ability to withstand impact and water damage. See how it withstands rough handling in transit and erection, minimising breakage in shipment and erection by unskilled labour at the most remote sites.

Test its MOISTURE RESISTANCE

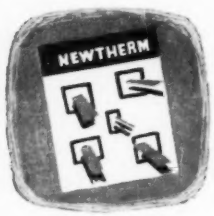
Even totally immersed in water, NEWTHERM retains much of its strength and rigidity. It does not become deformed when in contact with water, thus work-in-progress need not be covered. Especially on contracts where weather conditions would delay the application of insulation – NEWTHERM is the material to use.

Test its LIGHTNESS

Unusually light for such a high-efficiency material, NEWTHERM compares favourably in this respect with other insulants far inferior in strength. That means easier handling and fewer breakages—even the largest section is easily carried in one hand.

Test its EASE OF APPLICATION

Undoubtedly, NEWTHERM is one of the easiest of materials to apply. It is supplied in plastic form and in a wide range of standard-sized sections and slabs, smoothly finished and straight edged for immediate fitting. The finished job is very neat, with minimum joints, and appliers particularly appreciate the handleability of the material – especially in difficult situations.



READ ALL ABOUT NEWTHERM

in a specially prepared booklet. Sizes, compressive strength, thermal conductivity,—this and much more useful information can be on file if you write for your copy now, to the sole manufacturers Newalls Insulation Co. Ltd.

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***NEWTHERM** calcium silicate insulation*

. . . for temperatures up to 1400°F.

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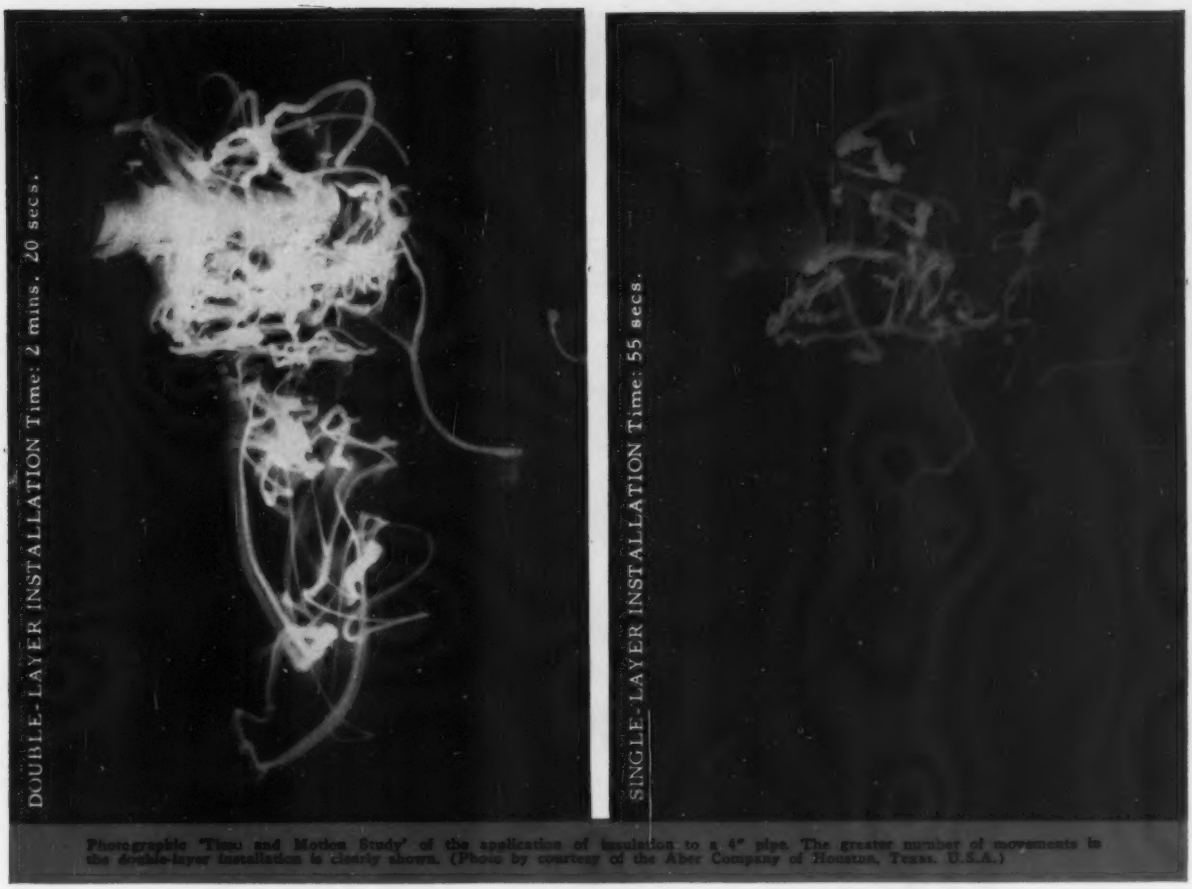

Photographic 'Time and Motion Study' of the application of insulation to a 4" pipe. The greater number of movements in the double-layer installation is clearly shown. (Photo by courtesy of the Aber Company of Houston, Texas, U.S.A.)

Insulation in a single layer! Caposite was developed by The Cape Asbestos Company to avoid the 'two-layer compromise' Caposite does it in one—saving considerably on installation time and costs. Caposite, the amosite asbestos insulation, is designed to withstand temperatures up to 1000° F. without loss of efficiency.

LOW JOINT LOSS

The fibrous edges of Caposite knit together at the joints giving a good heat seal and making staggered joints unnecessary.

EASY TO HANDLE

Its inherent strength makes it possible to handle Caposite in large sections for example at 2" thick for 30" n.p.s.—with very little damage and a further saving in installation costs.

One layer— Less work

CAPOSITE single-layer insulation

CAPE

THE CAPE ASBESTOS COMPANY LIMITED 114 & 116 Park Street, London W. 1, Grosvenor 6022
Cables: Incorrupt London

Enquiries in Canada to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario.
U.S.A.: North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois.

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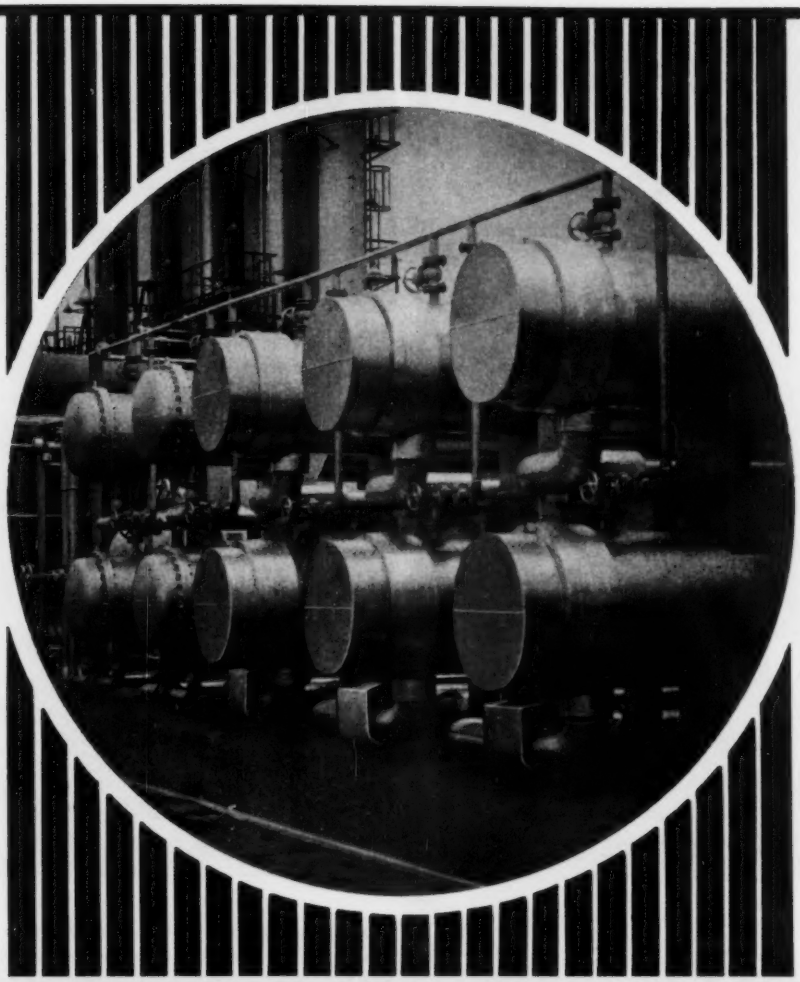

HEAT EXCHANGERS BY CHIYODA

Heat exchangers, coolers, condensers and other process equipment, standard or special, large or small, single or by the scores, are fabricated by Chiyoda at Chiyoda's new Kawasaki Factory with the most modern fabricating and testing equipment using fabrication methods backed by years of experience.

With an integrated organization staffed by specialists in every field plus lower man-hour costs, Chiyoda assures clients of early delivery, low maintenance cost, high operating efficiency and long life.

For your process equipment requirements anywhere in the world, CONTACT CHIYODA.

"Process Plants & Equipment Specialists"

CHIYODA CHEMICAL ENGINEERING & CONSTRUCTION CO., LTD.

PRESIDENT A. TAMAKI

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A Creative Job for Process Construction

To all industrialists interested in the construction of petroleum or petro-chemical plants, we extend an invitation to investigate the creative and technical knowledge of the Japan Gasoline Company. During the past 30 years the Japan Gasoline Company has built some of the best petroleum and petro-chemical plants in Japan, providing highly diversified service in building.....from the designing to the construction.....all in one favorable contract. An expert staff offers competent planning for every step of the way with the assurance to meet the demands of the most exacting customer.

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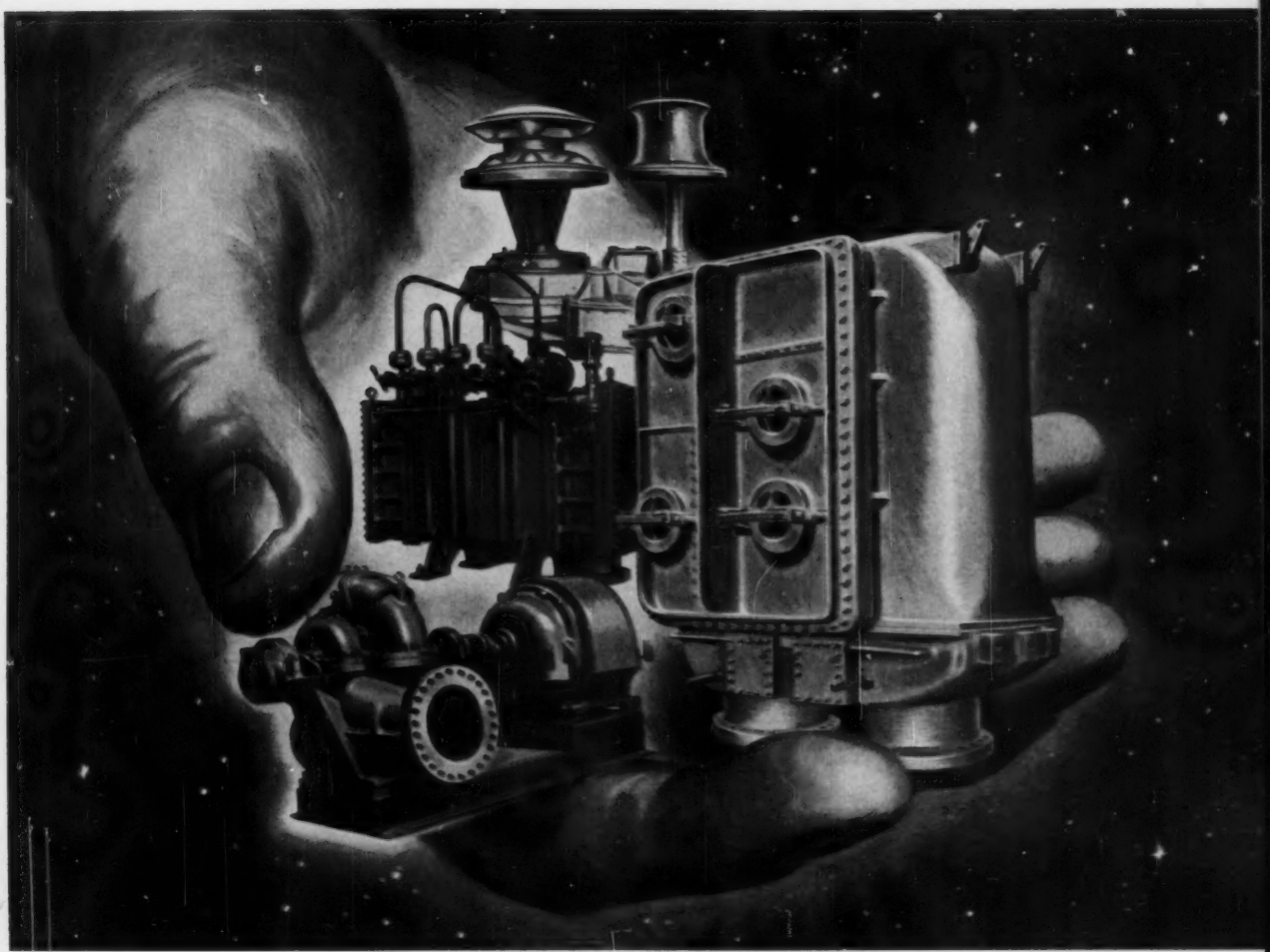
JAPAN GASOLINE CO., LTD.

New Otemachi Bldg., 4-2, Otemachi, Chiyoda-ku,
Tokyo, Japan. Cables: "ANTIKNOCK TOKYO"



NEW! ...the combination of

the combination of these two equipment in designing or procuring components for

Write today for this brochure:
The New Story of
C. H. Wheeler Mfg. Co. / Griscom-Russell Co.
c/o C. H. Wheeler Mfg. Co.
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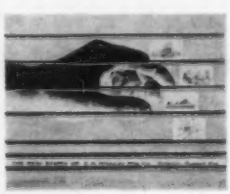

among the many components offered are: Condensers, Ejectors, Heat Exchangers — Bare Tube, Extended Surface Heat Exchangers,

For more data on advertised products, use Readers' Service Cards, last page.

C. H. Wheeler Mfg. Co. / Griscom-Russell Co.

lines offers important savings for management and engineering staffs engaged a variety of applications in power plants, marine, process and nuclear systems.

C. H. Wheeler Manufacturing Company, with 71 years' experience manufacturing condensers, ejectors, pumps and other components for the power, marine, process and nuclear industries, and Griscom-Russell, with 92 years' experience in the heat exchange field, are uniting to create an important pool of experience, products and services unmatched in industry today. The advantages offered by this combination are improved and increased selection, distribution and service, resulting in substantial savings for the current and potential customers of both companies.

C. H. Wheeler Mfg. Co./Griscom-Russell Co.

PHILADELPHIA, PENNSYLVANIA MASSILLON, OHIO

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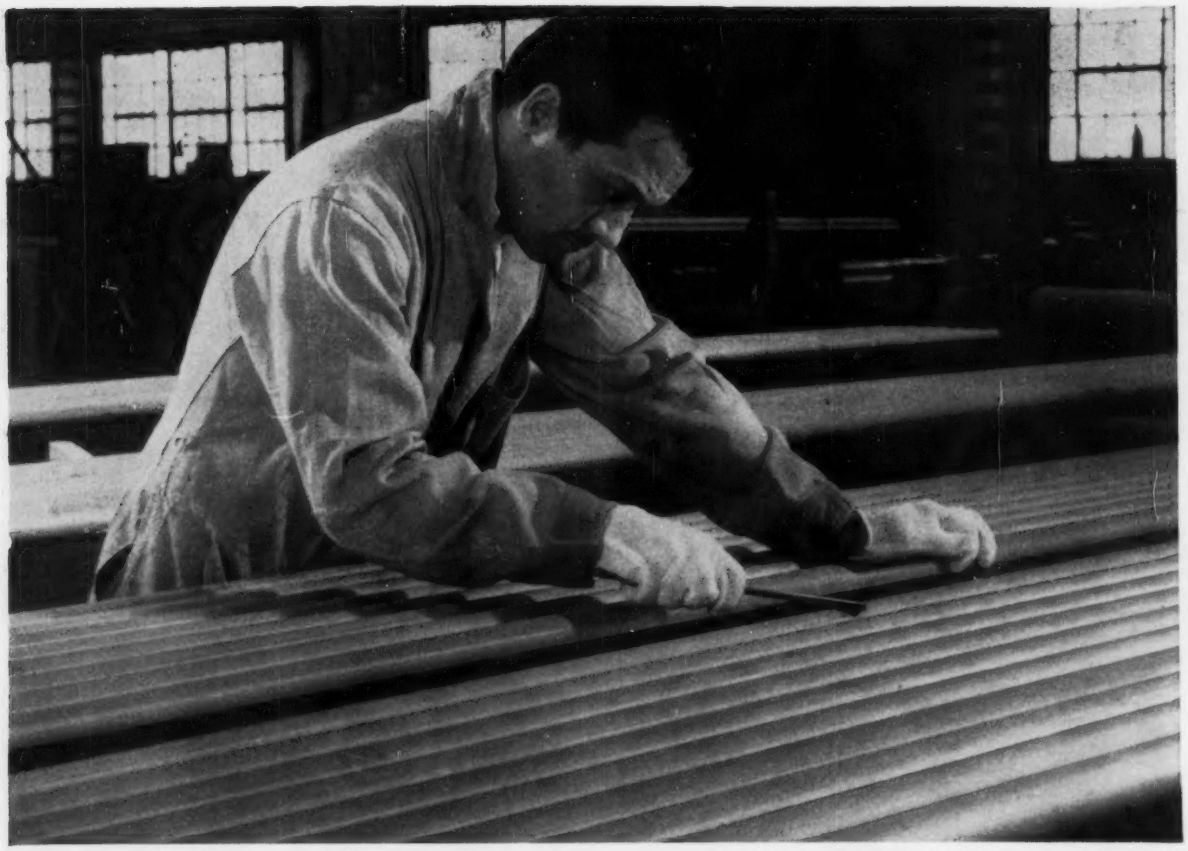


Stainless pressure tubing that gets white glove treatment

IF you're thinking of using stainless steel pressure tubing to solve a problem, make sure you get your money's worth. Timken® stainless steel pressure tubing is so carefully made it's literally handled with white gloves. That's typical of the quality that's built-in every step of the way. And you get this high internal quality and excellent surface finish, because:

1. **THE TIMKEN COMPANY** has one of the most modern, best-equipped seamless tube mills in the country.
2. **WE PIONEERED** in producing stainless steel tubing for pressure tube applications.
3. **MANY TECHNIQUES** we use are virtually unique in the steel industry.

Experts handle every production step—melting, piercing, finishing, testing, final inspection. The result is, you get the finest stainless pressure tubing you can buy. Tubing proved by performance in hundreds of applications.

Let Timken Company metallurgical experts help solve your stainless pressure tubing problems. You can get Timken stainless steel pressure tubing in a wide variety of sizes and grades—some not available anywhere else. Get the most for your money. Specify Timken stainless pressure tubing. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

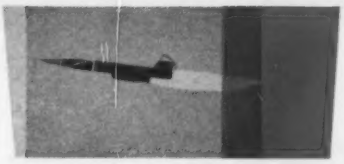
WHEN YOU BUY TIMKEN STEEL YOU GET . . .

1. Quality that's uniform from heat to heat, bar to bar, order to order
2. Service from the experts in specialty steels
3. Over 40 years experience in solving tough steel problems

TIMKEN® *Fine Alloy* STEEL

TIMKEN ALLOY STEEL AND SEAMLESS TUBING IS AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

BOEING BOMARC MISSILE---



ON TARGET...ON TIME...ON BUDGET

Designed to protect large areas against enemy bombers and missiles, the supersonic Boeing Bomarc air-defense missile is ready for operational service. Installation and check out of ground handling and ground support equipment at Otis Air Force Base is being performed by Catalytic, Engineers and Constructors. When specifications are rigid—or the need urgent—or when budgets are an important factor—consult

CATALYTIC
CONSTRUCTION COMPANY

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Catalytic *On-Time... On-Budget* Services for the metallurgical, chemical, petrochemical and oil refining industries: Project Analysis; Process Development; Process Design; Economic Studies; Engineering; Procurement; Construction.

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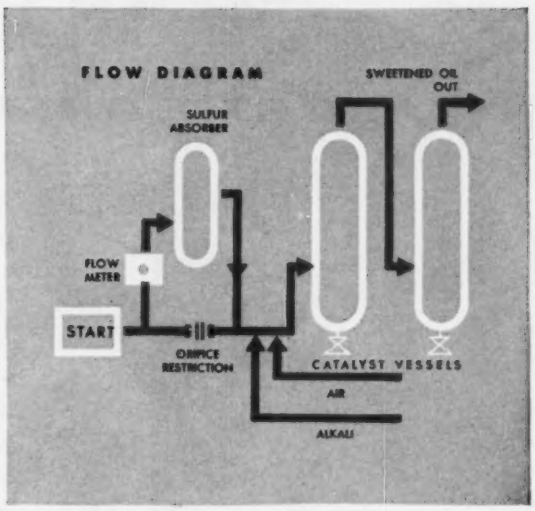
PRODUCT IMPROVEMENT WITH

PETRECO



IF SWEETENING IS ONE OF YOUR REFINERY PROBLEMS...

these facts about PETRECO* BENDER Catalytic Sweetening† may show you the answer:

LOW OPERATING COSTS: The average treating costs of Petreco Bender treating units are about 0.5 cents per barrel. Copper chloride or doctor treating costs, exclusive of amortization, generally exceed 1.0 cents per barrel. *The value of the volume loss in doctor treating alone often exceeds the total operation and amortization costs of Petreco Bender catalytic sweetening.*

SWEET NON-CORROSIVE PRODUCT: As compared to doctor treating, less sulfur is used, resulting in the delivery of a consistently non-corrosive product. *The use of less sulfur also lessens octane loss.*

ELIMINATES AIR AND WATER POLLUTION: Processing is in a closed system, eliminating air pollution and the attendant safety hazards. This eliminates open batch type agitators, thereby assisting in safety programs. *There is no "black strap" carry-over or carry-under to contaminate waste disposal systems.*

The product from the Petreco Bender unit is low in trace metal ions. Where a water wash is required to meet local product specifications, emulsion problems are not encountered due to the cleanliness of the Bender treated oil.

The only spent alkali withdrawn from the Bender unit each day is the small amount not consumed in the process.

HIGH YIELD: There is no volume loss in the system other than sampling and spillage. The volume loss in other sweetening processes is the greatest expense factor.

CONTINUOUS REGENERATION NOT NECESSARY: The catalyst retains its activity for long periods of time. This is made possible by the continuous addition of small quantities of air and alkali. Catalyst life without reactivation is usually two years or more. *Two Petreco Bender plants have been operating for over three years without any reactivation of the original catalyst.*

LOW INSTALLATION COST: *Unit cost for new equipment is comparatively low, ranging from $15 to $30 per barrel of daily throughput capacity.* If existing vessels are available and appropriate for conversion, this cost can be substantially reduced. Very often the charge may be taken directly from a distillation unit with existing pumps, exchangers and instrumentation, reducing the installation cost further.

SMALL TREATING AREA REQUIRED: Where ground areas are congested, the area occupied by any treating unit is of great importance. The plot dimensions for a 5,000 bpd Petreco Bender unit, for example, would be approximately 20′ x 35′.

*PETRECO *is a registered trademark of Petrolite Corporation.*

† *For middle range distillate streams such as kerosine, stove oil, light gas oil, No. 2 fuel oil, coker naphtha and catalytic gasoline.*

B-60-2

PETROLITE CORPORATION

PETRECO DIVISION

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1390 East Burnett Street (P.O. Box 7216), Long Beach 7, California

CANADA: Petreco, 4528 Stanley Drive, Calgary, Alberta
COLOMBIA: South American Petrolite Corporation, Bogota
ENGLAND: Petrolite Limited, 20 Savile Row, London W.1
GERMANY: Petrolite Anlagenbau und Vertriebsgesellschaft m.b.H., Frankfurt a. M.
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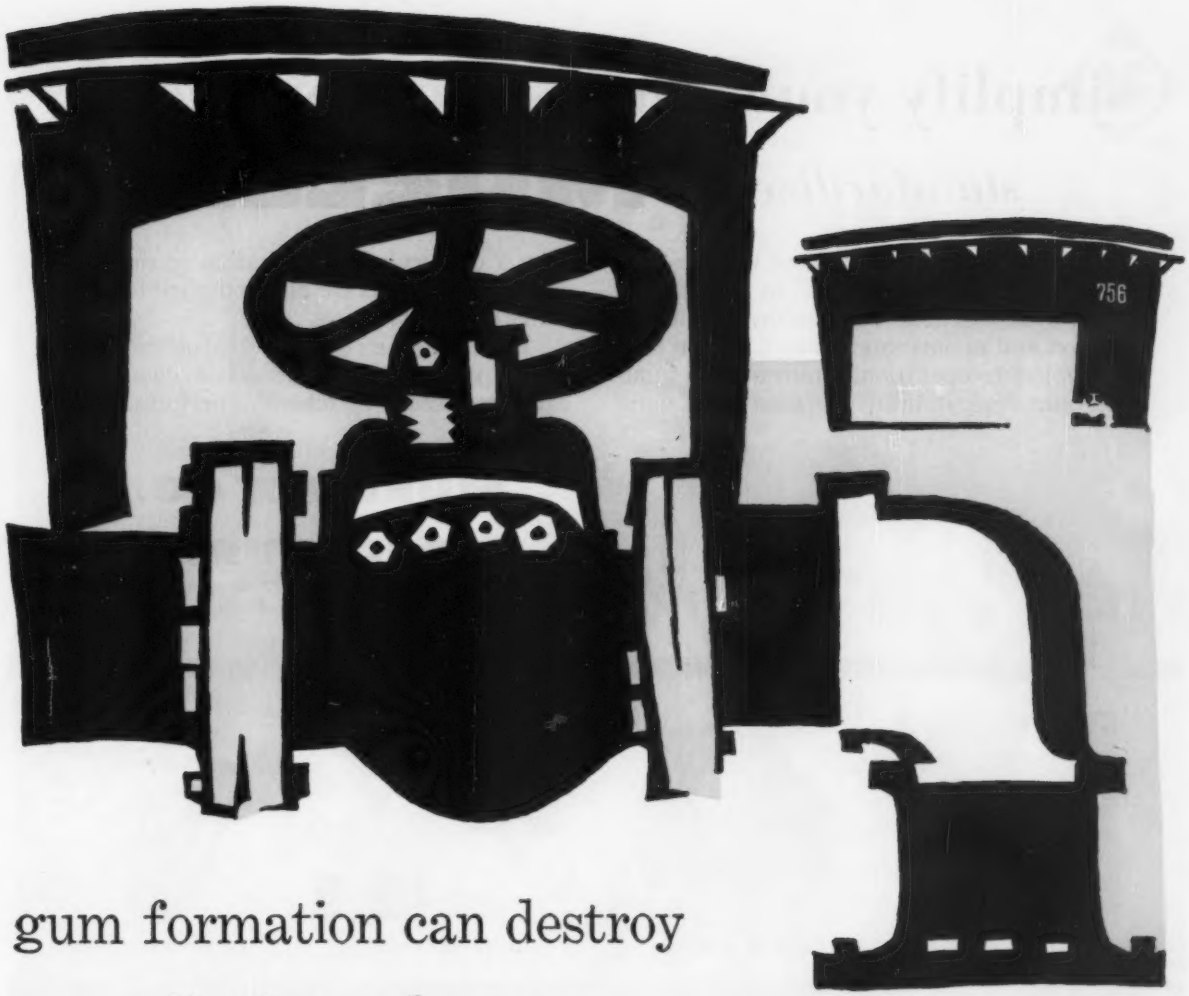


gum formation can destroy
a gasoline's good name...
protect yours with **Tenamene** Eastman gasoline additives

Why *Eastman* gasoline additives? Three good reasons.

1 Eastman offers you every principal type of gum inhibitor in commercial use today.

2 Eastman, as a basic manufacturer of the additives it supplies, maintains complete control every step of the way, assuring you of a uniform product and consistent additive performance.

3 Eastman petroleum specialists provide in-refinery technical service to make certain you obtain the most efficient use of the additives you buy. Ask them, for example, about the cost-cutting possibilities of bulk delivery.

You'll find Eastman petroleum specialists give you unequaled technical service because inhibition of gum formation is their only interest. For further information, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tenn.; Atlanta; Chicago; Cincinnati; Cleveland; Detroit; Framingham, Mass.; Greensboro, N. C.; Houston; New York; St. Louis. **West Coast: Wilson Meyer Co.,** San Francisco; Denver; Los Angeles; Phoenix; Salt Lake City; Seattle.

simplify your water system problems

standardize on MUELLER®

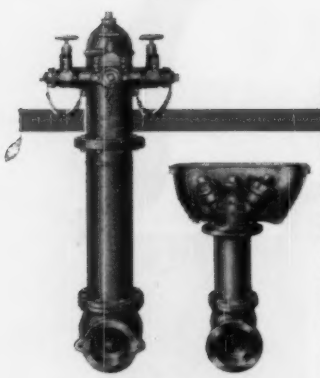
Install components in your water system that are "design-matched" to go together and work together. You can simplify installation and maintenance. You can gain long trouble-free operation. Uniform high quality and dependability are assured by more than a century of specialization in the design and manufacture of a complete line of water control products.

Look at the complete Mueller line before you specify. Consider a complete Mueller system—matched for performance.

MUELLER CO.

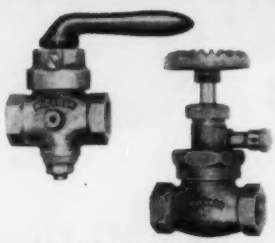
DECATUR, ILL.

Factories at: Decatur, Chattanooga, Los Angeles;
In Canada: Mueller, Limited, Sarnia, Ontario.

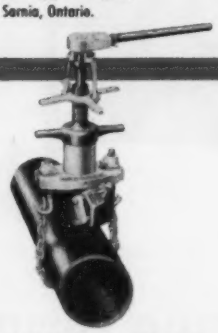


FIRE HYDRANTS

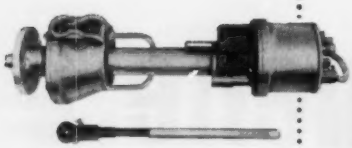
CHECK VALVES



PLUMBING VALVES

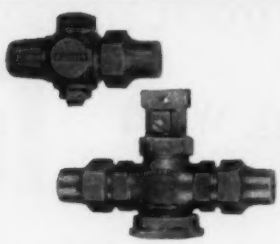


TAPPING MACHINES



DRILLING MACHINES

GATE VALVES

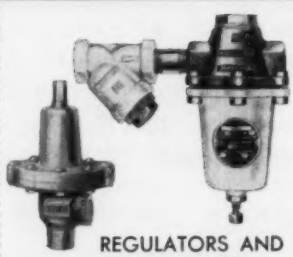


BRASS STOPS

TAPPING SLEEVES AND VALVES

***specify* MUELLER**
"matched-design" water products

Write for complete information and specifications on Mueller products for water and fire protection systems.

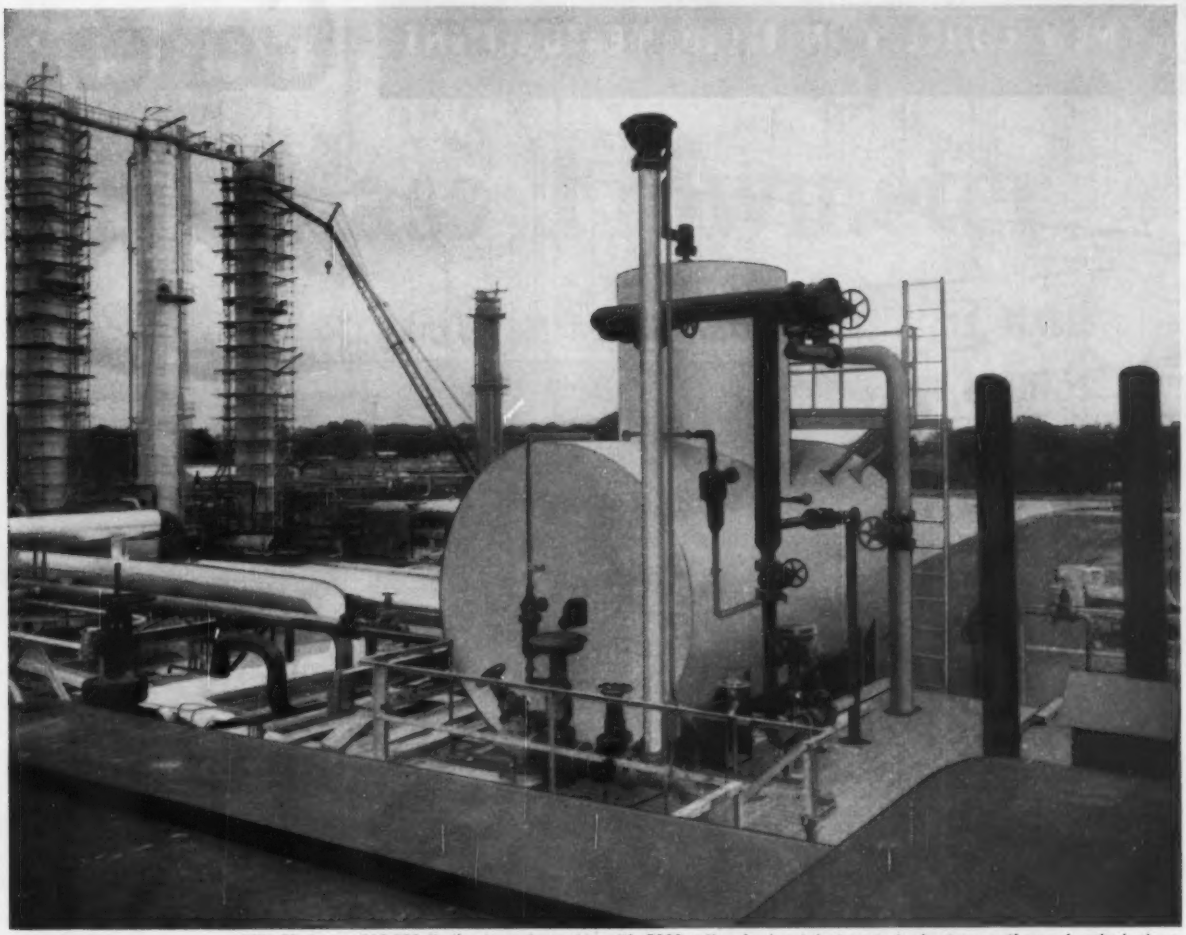


REGULATORS AND RELIEF VALVES

Mueller Co. also makes a full line of No-Blo® products for the petroleum and gas distribution industry.

ALLIS-CHALMERS

A-1233



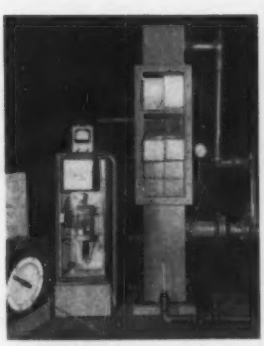
Allis-Chalmers 215,000 lb./hr. tray deaerator with 7200-gallon horizontal storage tank at a southern chemical plant.

Corrosive gases removed

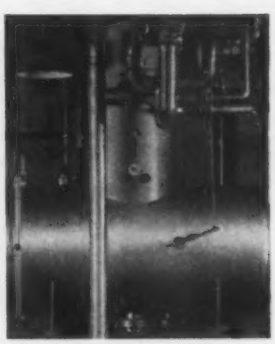
from boiler feedwater with Allis-Chalmers deaerators

Positive corrosive gas removal by Allis-Chalmers tray-type deaerators is proved by a pilot unit (below) equipped with a continuous oxygen analyzer and recorder. It utilizes unique counterflow design for thoroughly scrubbing dissolved gases from the water surface. Design produces maximum heating of water with minimum of steam loss in venting. Effective deaeration is guaranteed under all loads.

Ruggedly constructed, A-C deaerators employ 16-gauge 18-8 stainless steel on all equipment exposed to corrosive gases. No moving parts assures quiet operation, minimum maintenance. Inspection is easy through ample access doors and manholes. Service? Seventy-seven district offices throughout the nation. Your A-C water conditioning engineer can give you full deaerator details. **Allis-Chalmers,** Power Equipment Division, Milwaukee 1, Wisconsin.



Pilot deaerator permits evaluation of tray designs.

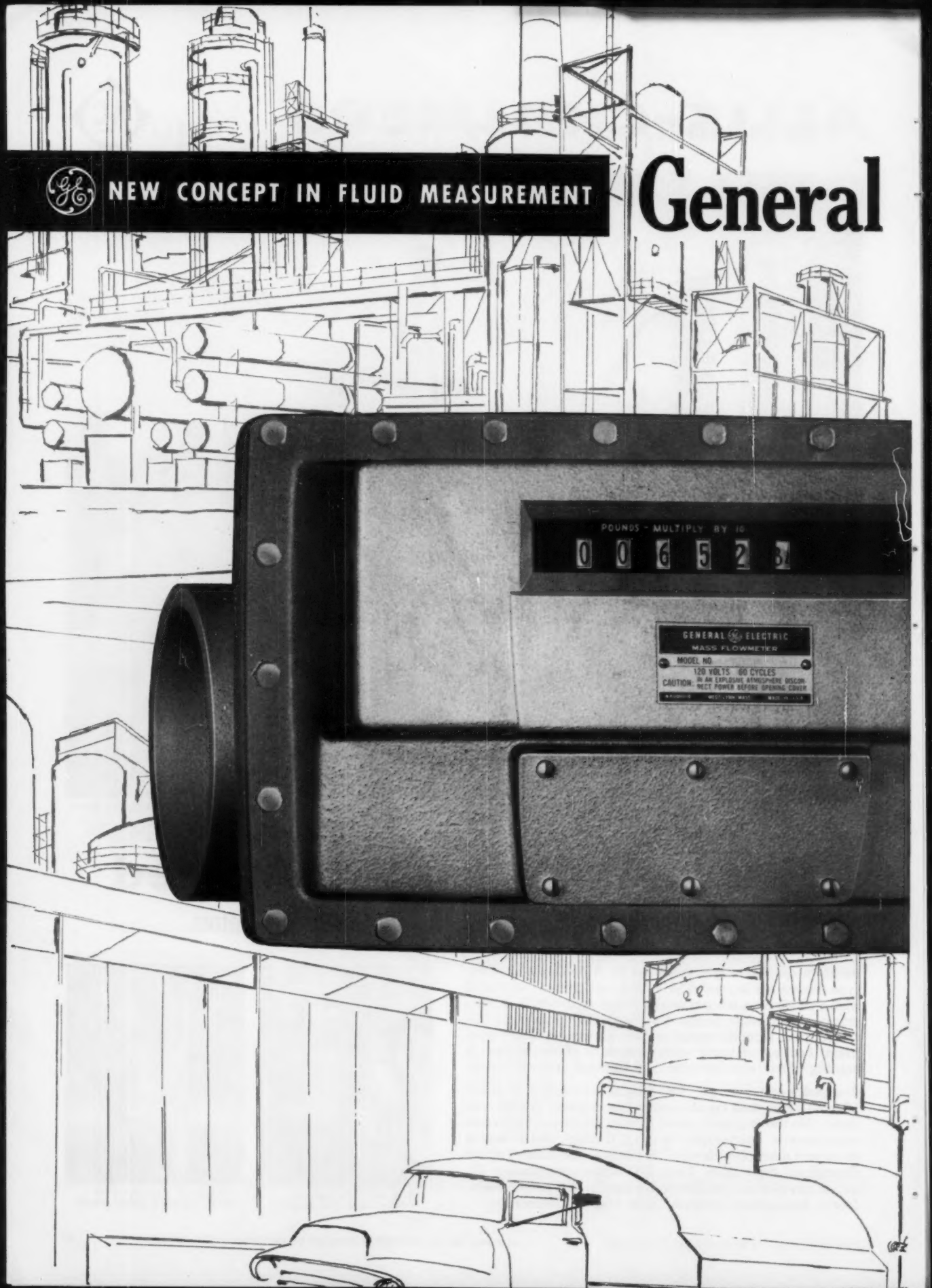


"Standard" deaerators for small industrial power plants.

For more data on advertised products, use Readers' Service Cards, last page.

NEW CONCEPT IN FLUID MEASUREMENT

General


POUNDS - MULTIPLY BY 10
0 0 6 5 2 3
GENERAL ELECTRIC
MASS FLOWMETER
MODEL NO.
120 VOLTS 60 CYCLES
CAUTION: IN AN EXPLOSIVE ATMOSPHERE DISCONNECT POWER BEFORE OPENING COVER

Electric Gyro-Integrating True Mass Flowmeter

ACCURATELY MEASURES FLOW OF LIQUIDS, GASES AND LIQUEFIED GASES . . . DIRECTLY IN POUNDS

This new General Electric meter provides continuous local or remote totalization and registration of gas and liquid flow by weight within ±1 percent accuracy over wide variations in flow rate, density, pressure, temperature and viscosity.

PROCESS FLOW MEASUREMENT—Ideal for applications in the petroleum, chemical, and petro-chemical industries, the new mass flowmeter completely eliminates time-consuming orifice calculations and possible costly errors in correcting volumetric readings for fluid variables. It does away with the need for recalibration when process and flow conditions change, too. And it puts an end to supercompressibility problems.

What's more, the new flowmeter lets you make complete and accurate material balances easily because it operates on a mass measurement principle and gives you your answer *in pounds*. No more measuring liquids in gallons or barrels, gases in cubic feet, then making tedious conversions in order to equate the two. Measurement of both by weight allows direct comparison.

LIQUEFIED GAS MEASUREMENT—You can measure the weight of truck and tank car loading of your liquefied gas products easier and faster with General Electric's new mass flowmeter than with present volumetric-type meters or expensive and cumbersome scale installations. The meter registers the total loaded weight directly in pounds. Then, operating from a battery-inverter power supply, the flowmeter can be used right on your truck when unloading, for easy and accurate deliveries. And no precautions are necessary to protect the meter from high velocity caused by "flashing."

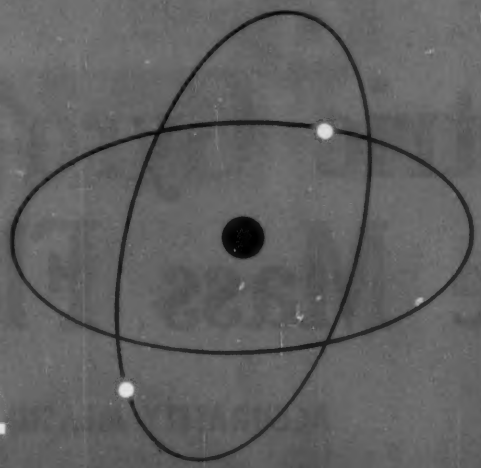
An outgrowth of General Electric research into mass flow measurement, this new meter has already been proved on such fluids as natural gas, ethylene, Freon, liquid carbon dioxide, naphtha and jet fuel.

For complete sales and service information, contact your nearby General Electric Apparatus Sales Office, or write for bulletin GEA-6925A, Section 599-02, General Electric Company, Schenectady 5, N. Y. On applications in the natural gas industry, contact Black, Sivalls and Bryson, Inc., Kansas City, Missouri.

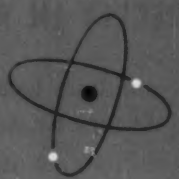
FOR QUALITY... PRODUCTIVITY ...PROFIT — INSTRUMENTATION FOR AUTOMATION

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC



hē'li-ŭm



When you consider Helium-Recovery you will automatically think of Stearns-Roger.

Most of the operating helium plants in the free world have been built by Stearns-Roger. In this one organization is collected the cryogenic knowledge, experience and practical background to engineer and construct economical and satisfactory helium plants.

Stearns-Roger can provide you with reliable designs, investment studies and overall assistance in helium, hydrogen, natural gas and rare gas problems.

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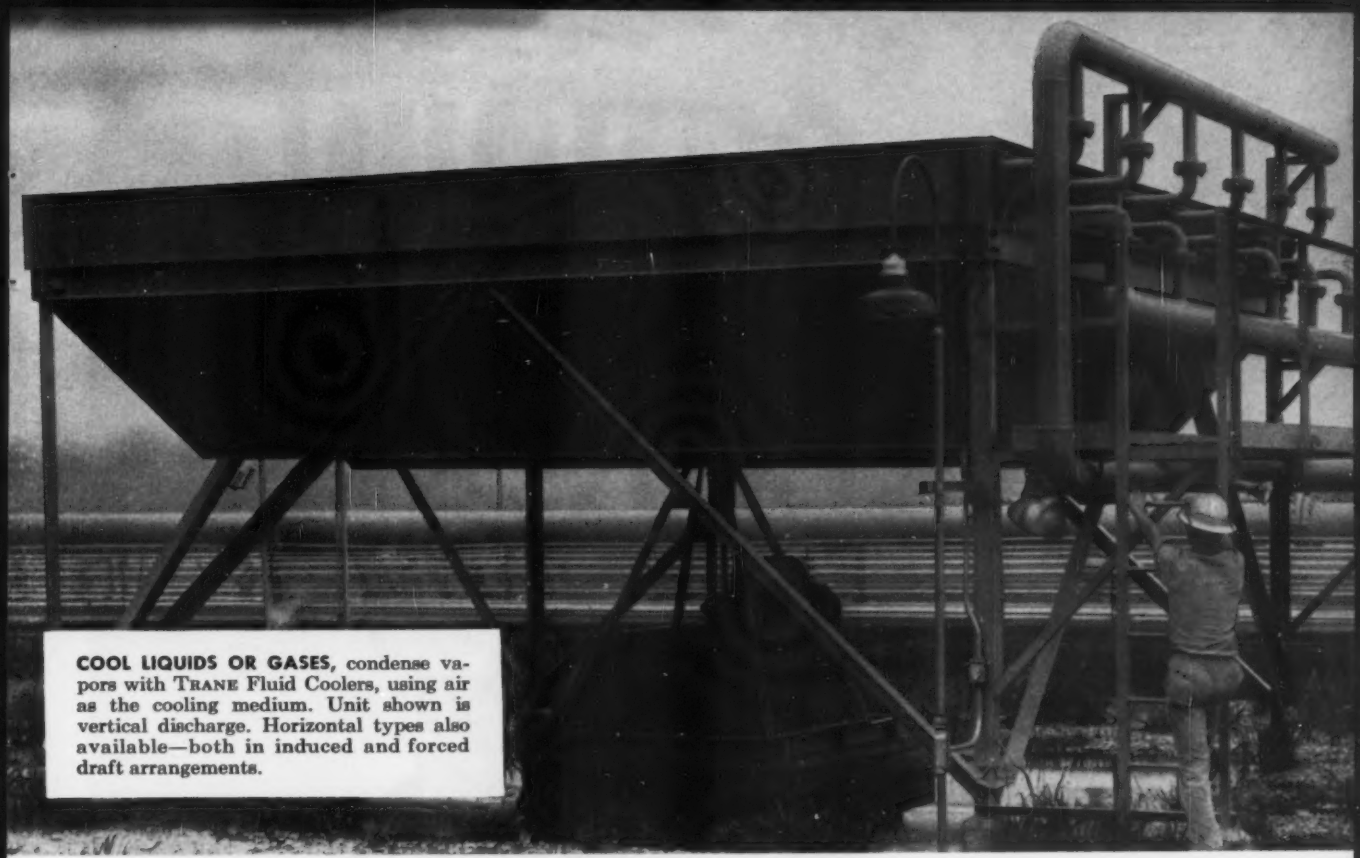


COOL LIQUIDS OR GASES, condense vapors with TRANE Fluid Coolers, using air as the cooling medium. Unit shown is vertical discharge. Horizontal types also available—both in induced and forced draft arrangements.

Lower erection costs, operating costs ...with versatile Trane Fluid Coolers!

Air-cooling now solving water supply problems for many refineries, petrochemical and natural gasoline plants

More and more engineers and plant designers are finding that *air-cooled heat exchangers* eliminate water supply and maintenance problems encountered with conventional cooling towers. These engineers report a substantial net reduction in over-all cooling costs and water consumption. Here are some of the ways TRANE Fluid Coolers are helping to solve heat transfer problems in many refineries and plants:

- **Low first cost.** Erection is simpler; fan, motor and gearbox are factory-aligned on a single metal base. Framework parts are pre-drilled, match-marked. Compact, simple, TRANE Coolers can often be installed on roofs, cutting real estate costs.
- **Lower operating costs.** Equipment needs only periodic cleaning of fin-tube surface. No need for special crews, maintenance facilities or spare parts. And TRANE Fluid Coolers have a life expectancy of 15-20 years—compared with 7-10 years for cooling towers.
- **Superior performance.** TRANE Coolers available with Admiralty stainless and carbon steel tubing to meet the most exacting specifications. Units are now in use in Canada and Bermuda—meeting extreme weather conditions. They also solve the problem of corrosion caused by salt-air atmosphere.

WANT MORE FACTS?

New Catalog S-395 has complete specification and application data on TRANE Fluid Coolers. For your copy, write TRANE, La Crosse, Wisconsin. Or just call your nearby TRANE Sales Office.

For any air condition, turn to

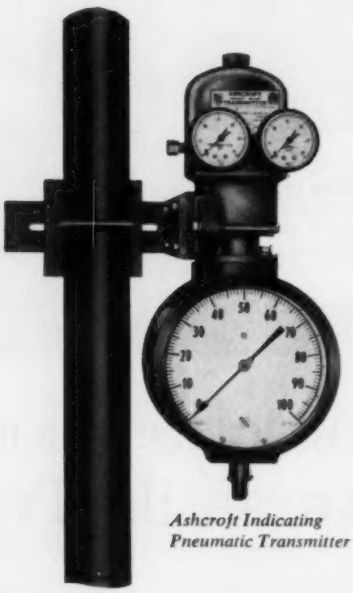
TRANE

MANUFACTURING ENGINEERS OF AIR CONDITIONING, HEATING, VENTILATING AND HEAT TRANSFER EQUIPMENT

THE TRANE COMPANY, LA CROSSE, WIS. • SCRANTON MFG. DIV., SCRANTON, PA. • CLARKSVILLE MFG. DIV., CLARKSVILLE, TENN. • TRANE COMPANY OF CANADA, LIMITED, TORONTO • 97 U. S. AND 19 CANADIAN OFFICES

signal

ASHCROFT PNEUMATIC TRANSMITTERS give you a true primary and transmitted signal for indication or control



Ashcroft Indicating Pneumatic Transmitter

action

Now—detect with precision accuracy the slightest change in primary pressure or temperature. Transmit this signal quickly to your indicators or controllers. Ashcroft Pneumatic Transmitters achieve these results for you at the lowest initial and operating costs.

Full-range, solid-front indicating and totally accessible nonindicating transmitters eliminate the need for costly high pressure lines, yet permit complete monitoring of process conditions in remote areas.

Narrow-span Ashcroft Transmitters are expressly designed with highest sensitivity and repeatability for the most accurate primary signal feed to controllers. You get better control and purer, lower-cost final products.

Only in Ashcroft Pneumatic Transmitters can you get the wide choice of Ashcroft Duragauge Bourdon tubes or American mercury or gas-actuated systems for sensing pressure or temperature conditions. You also get a time-proven, obstruction-proof, force-balance, nonbleed relay for economical, maintenance-free 3-15 psi or 3-27 psi signal transmission.

Write for factful Bulletins 360 and 361 or ask your nearby Ashcroft Distributor to help you select the right transmitters and receiver gauges for your specific requirements.

MANNING MAXWELL & MOORE INC. TRADE MARK

ASHCROFT PNEUMATIC TRANSMITTERS

A product of

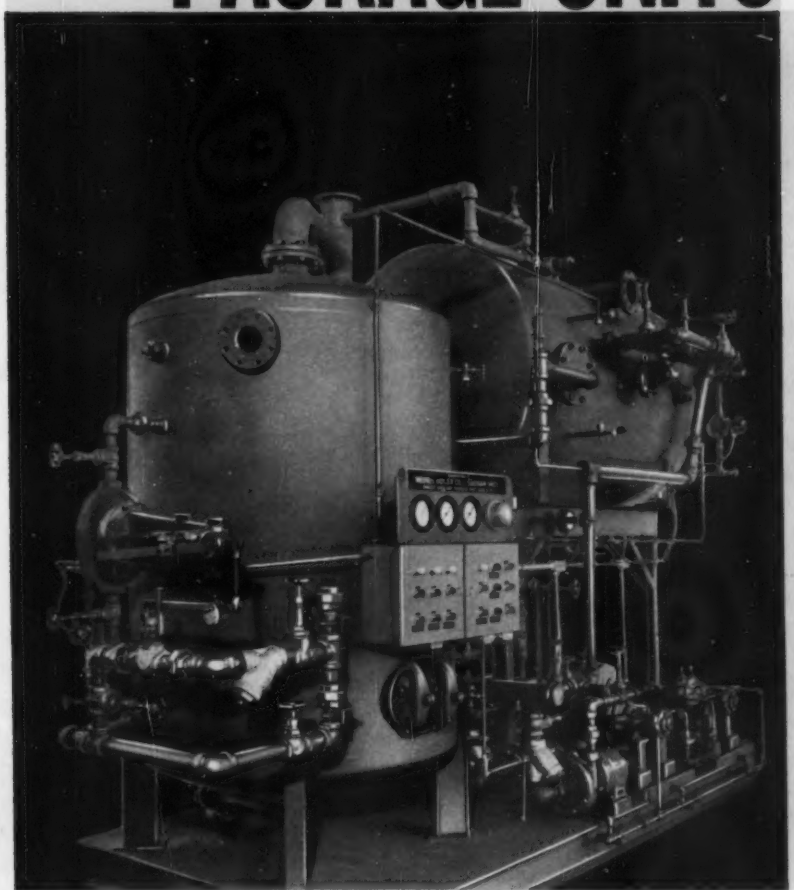
MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

WICKES
BOILER AUXILIARY PACKAGE UNITS

standard



Save On First Cost • Engineering • Building Space • Construction Time • Operating and Maintenance Cost

Wickes Boiler Co. now offers a packaged system of various compact combinations of DEAERATING FEED WATER HEATERS, BOILER FEED PUMPS, CONDENSATE SURGE TANKS and BLOW-OFF TANKS. Standard units available for steam plants of 10,000 to 100,000 lbs. of steam per hour capacity and steam pressure to 300 PSIG. Information on special units of higher capacities and pressures upon request. Each unit is shop-assembled on a structural steel base, completely piped and wired and equipped with all necessary controls and an instrument panel.

173

Write today for Bulletin 59-1, which gives detailed engineering information on all three models of Wickes Boiler Auxiliary Package Units.

WICKES BOILER CO., SAGINAW 18, MICHIGAN
Division of The Wickes Corporation

WICKES

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Control Combustion with AMOCO 541 Gasoline Additive

Get these 9 big manufacturing benefits too

When you blend AMOCO 541 Additive with your gasoline, you're giving your customers top-flight control of abnormal combustion. You're also giving yourself 9 important manufacturing advantages.

1. Treating costs to achieve the same performance are less with AMOCO 541 than with other combustion aids.

2. AMOCO 541 is easy to use. It is offered ready to be blended directly with gasoline. There is no additional handling. It can be blended with present blending equipment.

3. Octane level need not be increased since AMOCO 541 does not increase engine octane requirement.

4. AMOCO 541 is compatible with all other additives normally blended with gasoline.

5. It is not extracted by water.

6. AMOCO 541 has no adverse effect on clarity of gasoline. It does not stabilize water haze.

7. The additive does not increase gum content nor does it affect corrosion characteristics of gasoline in contact with copper, steel or zinc.

8. Gasoline volatility is not affected.

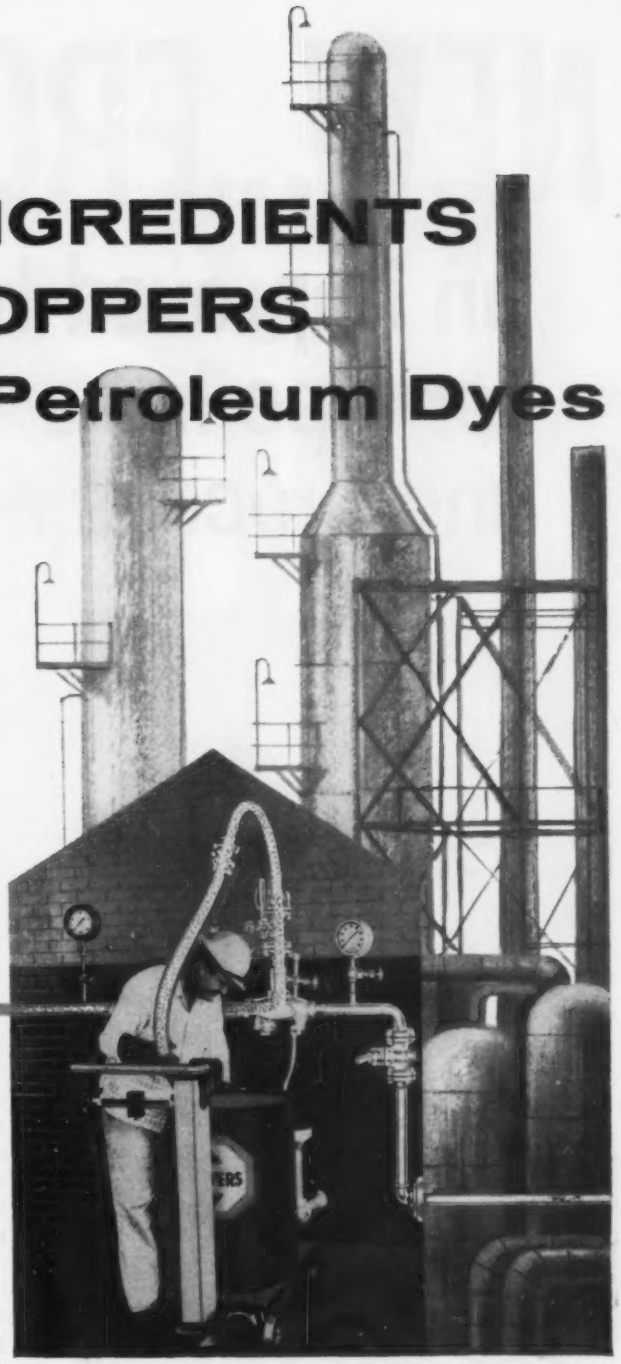
9. The additive has no effect on gasoline dye.

Get more facts about AMOCO 541 Gasoline Additive. Your inquiry will receive immediate attention.

AMOCO CHEMICALS

AMOCO CHEMICALS CORPORATION
910 South Michigan Avenue, Chicago 80, Illinois

PLUS INGREDIENTS in KOPPERS Gran-U-Flow™ Petroleum Dyes



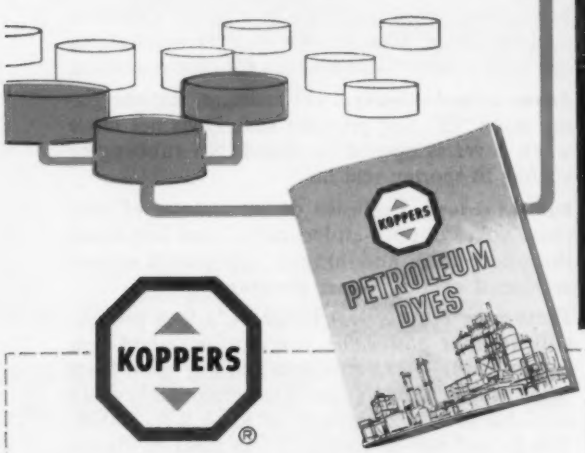
There *are* PLUS INGREDIENTS . . . in Koppers Gran-U-Flow Dyes . . . extra reasons why you should specify Koppers:

- unvarying uniformity . . . batch-to-batch
- high tinctorial strength
- dustless
- low benzene insolubles
- high solubility
- granular (Gran-U-Flow) . . . for *easy* flow

Whether you use petroleum dyes for gasoline, anti-freeze or a wide range of lubricants . . . for corporate identity, improvement of product appearance or ease of identification . . . you owe it to yourself to investigate the superior advantages of Koppers Gran-U-Flow Dyes.

Dye drums are color coded and designed for eductor systems in refineries.

Clip the coupon below to your company letterhead for a booklet showing newest eductor techniques. A free laboratory kit is also available. VMA 6962



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KOPPERS COMPANY, INC.

Chemicals and Dyestuffs Division

KOPPERS BUILDING, PITTSBURGH 19, PA. • **Plant:** Lock Haven, Pa.
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☐ Please send booklet on newest eductor techniques.

☐ Please send free laboratory kit for Gran-U-Flow Petroleum Dyes.

Name_____ Title_____

Company_____

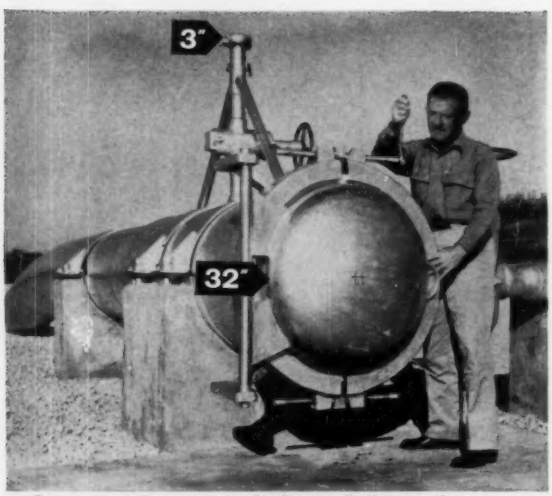
Address_____

City_____ Zone_____ State_____

CLIP TO YOUR COMPANY LETTERHEAD.
Mail to our Pittsburgh office or nearest branch.

NEW...FROM TUBE

an improved hinged closure for pipe lines, piping and process equipment



One man, using any standard wrench, can easily open or close the TUBE-TURN *Hinged Closure. Has important safety features, too!*

For vertical applications, TUBE-TURN *Hinged Closures can be equipped with spring-loaded, counterbalanced caps.*

Tube Turns announces a new line of hinged closures with important advantages for pipe lines, piping and process equipment wherever frequent access is required or where the use of blind flanges would be cumbersome and time consuming. Proved in scores of applications by major companies, the unique TUBE-TURN* Hinged Closure provides these benefits:

Saves installation time. Light weight assembly easier to handle. Completely fabricated . . . ready to install. Requires only one butt-weld to join to pipe, tank or vessel opening.

Saves operating cost. One man, using a standard wrench, can easily open or close the largest size closure in a few minutes. No threads or lugs to engage or flanges to line up. No parts to fail. No hammering or tugging. Can be adapted to motorized operation. Closures for vertical applications can have counterbalanced caps for easy operation.

Saves on maintenance. Oil resistant, self-energizing static "O" ring provides seal. Does not move when cover is opened or closed. No rubbing or chafing to shorten seal life.

Built-in safety. Exclusive design features of two-piece yoke, double-ended right- and left-hand threaded bolts and hinged cap guard against accidental opening under pressure.

These new TUBE-TURN Hinged Closures provide still another *plus value* you can get when you specify TUBE-TURN products and buy them from your nearby Tube Turns' Distributor. They are available in sizes 2" through 42" for A.S.A. 150-lb, 300-lb and 600-lb service . . . in steel or alloys.

*"TUBE-TURN" and "tt" are trademarks of Tube Turns.

TURNS...

Another tt *plus value from...*

TUBE TURNS

DIVISION OF CHEMETRON CORPORATION

Louisville 1, Kentucky

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DISTRICT OFFICES: Edmonton • Montreal • Toronto

FREE BULLETIN... Complete information on the new line of TUBE-TURN Hinged Closures will be sent on request. Mail coupon.

TUBE TURNS, Dept. PR-3
224 E. Broadway • Louisville 1, Kentucky

Please send Bulletin TT956 on new TUBE-TURN Hinged Closures.

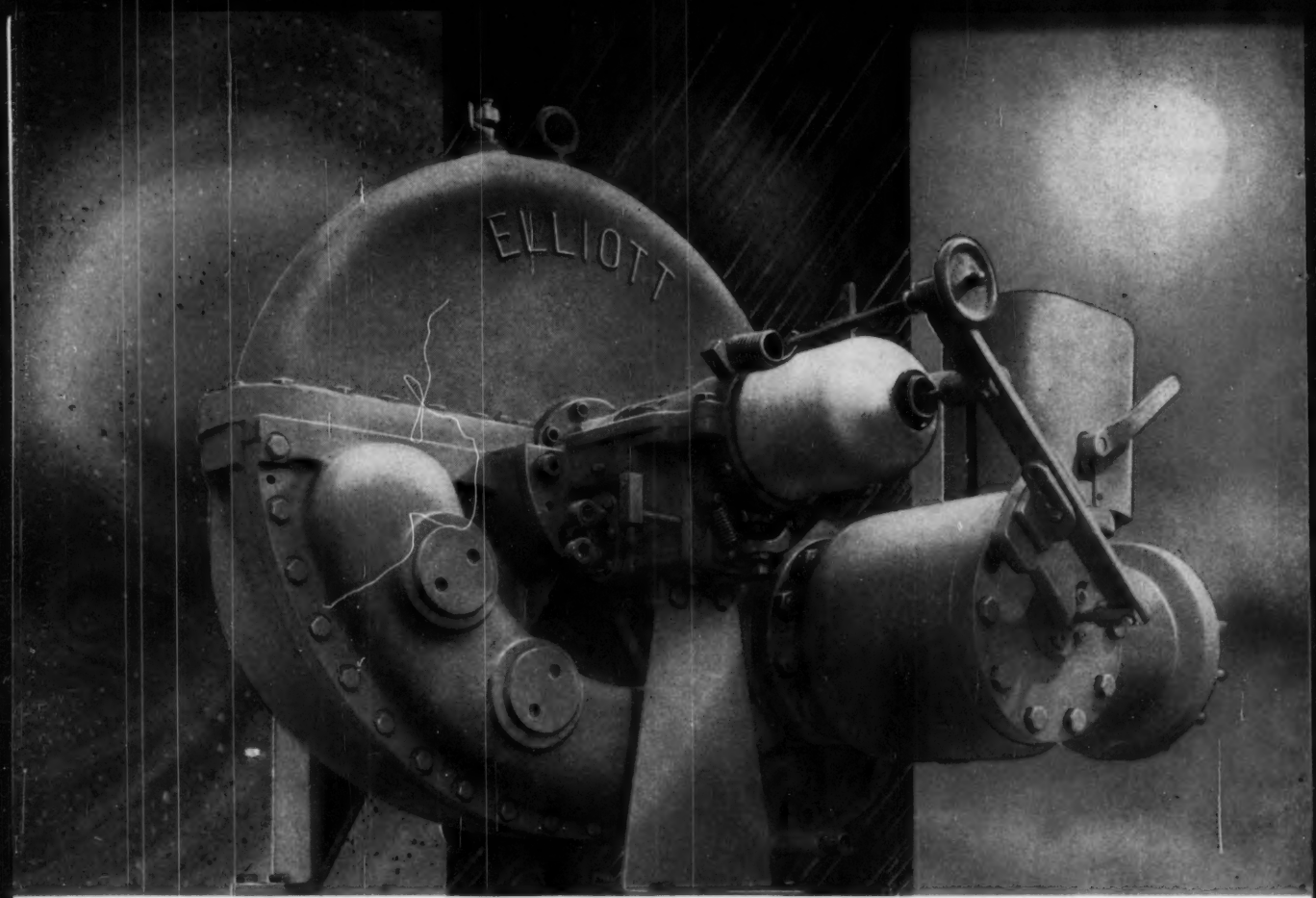
Company Name _____

Company Address _____

City _____ *Zone* ____ *State* _____

Your Name _____

Position _____

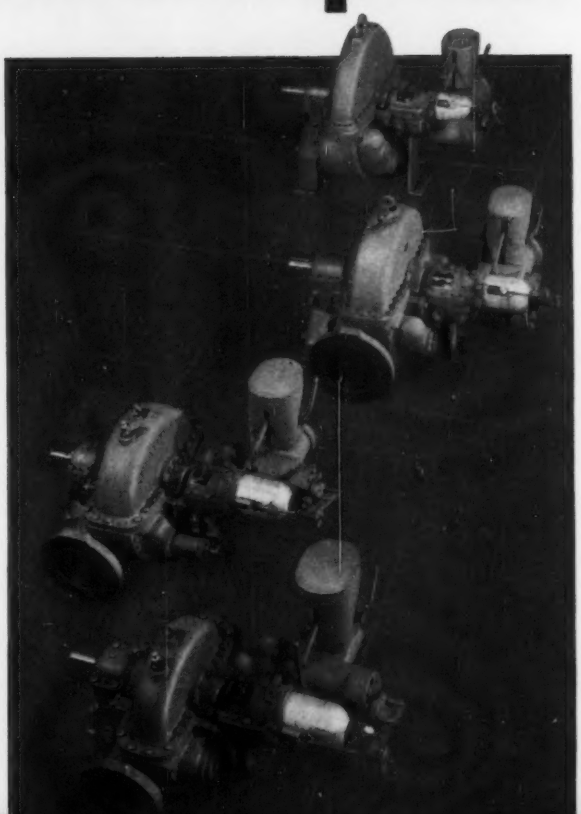


rugged and weatherproof

ELLIOTT YR TURBINES

Desert heat, arctic cold, driving rain and swirling dust don't faze rugged, dependable Elliott YR Turbines. Tightly sealed against dust, fumes and moisture . . . built strong and husky . . . these machines make dependable, economical drives for pumps, compressors, fans, line shafts, generators and other equipment.

The governor is simple and reliable, and is available in several modifications to match speed and pressure control requirements. YR turbines are designed for easy installation and service. Many key parts are interchangeable for various frame sizes. Four sizes are shown at the right. Write for descriptive bulletin H22-C.



In addition to the units illustrated here, Elliott makes single-stage turbines in special frames, reduction gears, multistage mechanical drive turbines to 50,000 hp, and turbine-generators through 44 mw.

ELLIOTT Company

JEANNETTE, PENNSYLVANIA H9-2

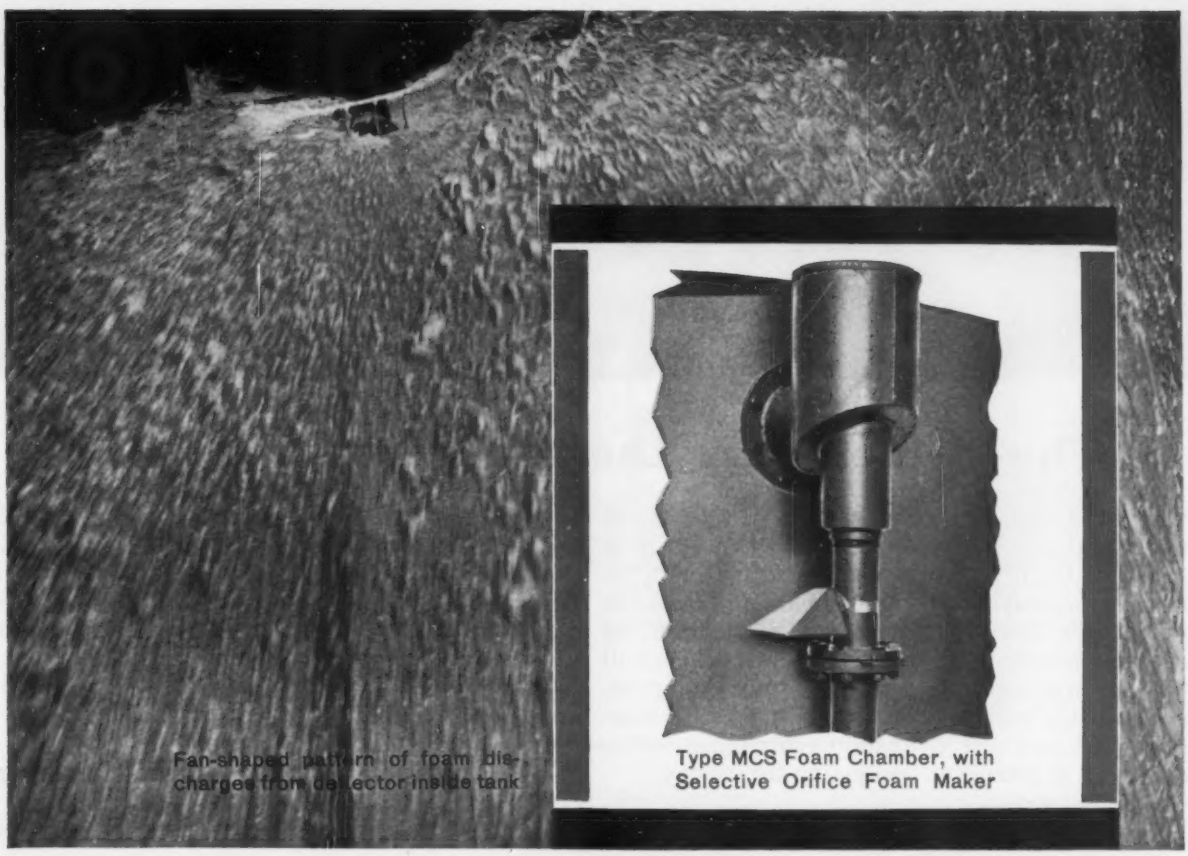
do your FOAM CHAMBERS measure up to these standards?

1. Are they vertical rather than horizontal, so that they won't snap off if the tank explodes? ☐ Yes ☐ No
2. Are they truly compact in design . . . reducing labor costs during installation? ☐ Yes ☐ No
3. Do they permit filling tanks to the top angle without immersing the glass diaphragm and running the consequent risk of loss of product in case of broken glass? ☐ Yes ☐ No
4. Do the deflectors spread foam in a fan-shape pattern to reduce submergence and turbulence? ☐ Yes ☐ No
5. Do they use positive pressure to break the glass diaphragm, instead of merely relying on water velocity? ☐ Yes ☐ No
6. Do they require minimum maintenance? ☐ Yes ☐ No

If you can answer YES in all cases, you already have National Aer-O-Foam Chambers. If not, you need them! For full information, write for Booklet E.

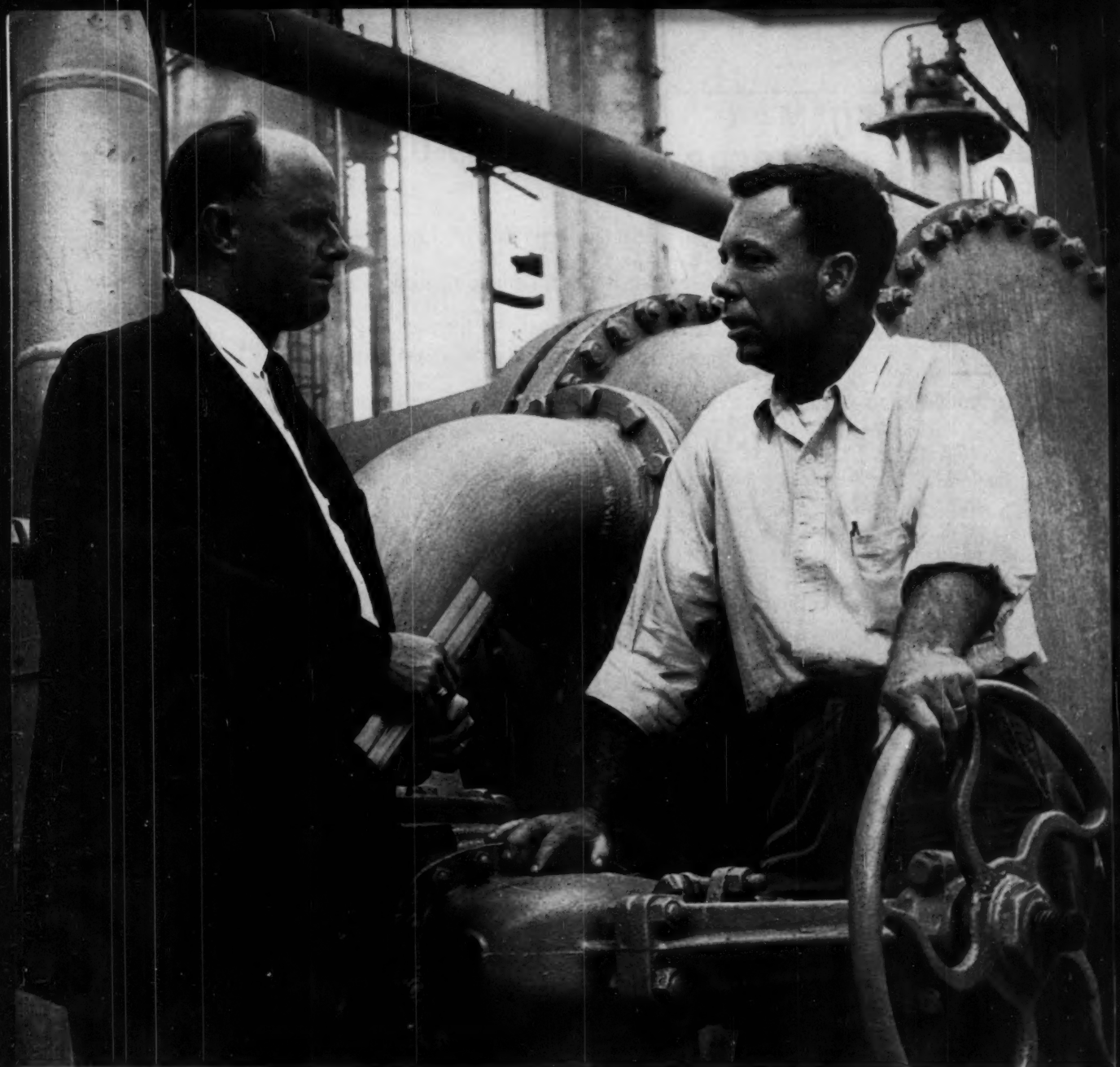
NATIONAL FOAM SYSTEM, INC.

West Chester, Pa.



Fan-shaped pattern of foam discharged from deflector inside tank

Type MCS Foam Chamber, with Selective Orifice Foam Maker



Photographed at Gulf Refinery, Philadelphia, Pa.

The golden rule that produces results...

Our golden rule is teamwork between refiners and Cyanamid. As a result of this teamwork, Cyanamid produced the first fully regenerative platinum reforming catalyst. Today Cyanamid's research efforts are directed toward the development of superior platinum reforming catalysts which will have general application in many reforming processes for the industry. Continued co-operation between refiners and Cyanamid contributes to the advances in petroleum processing technology.

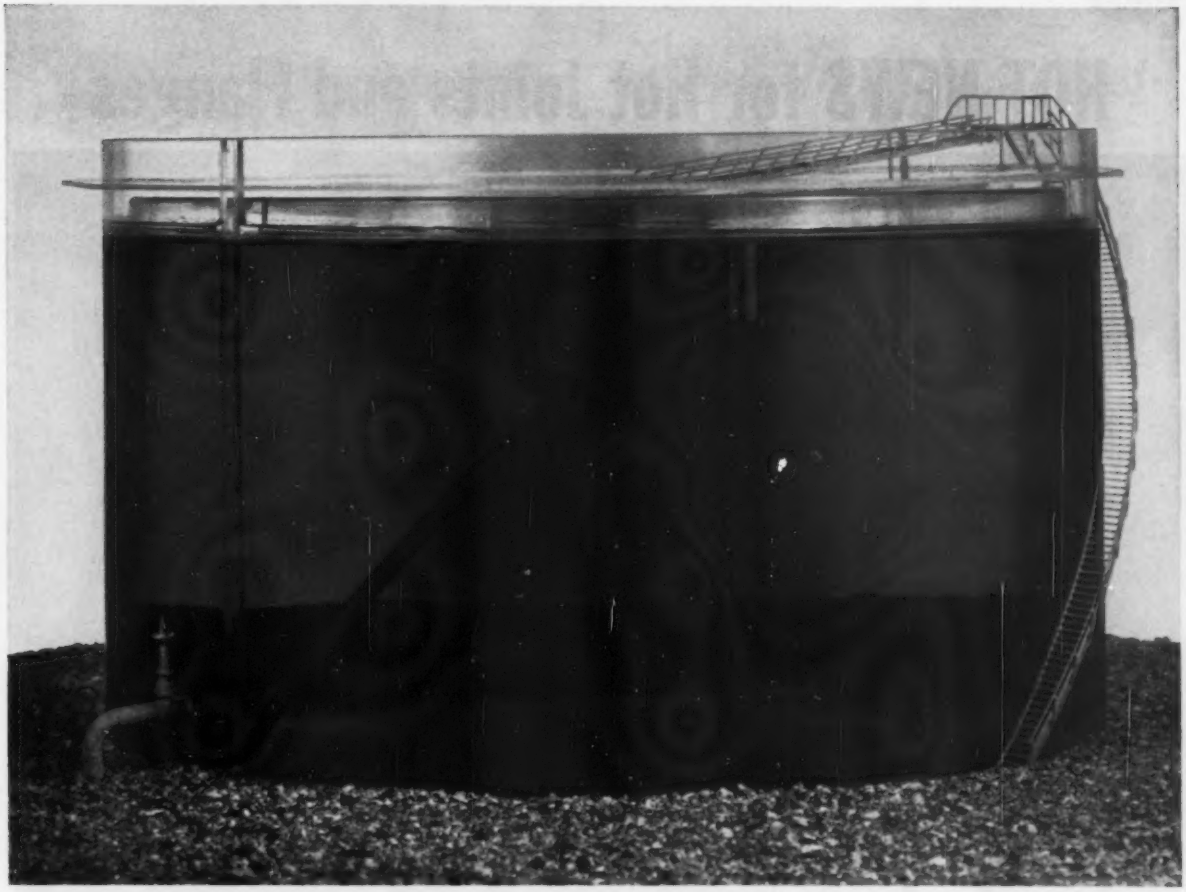
Symbolizing this co-operation is Cyanamid's salesman—the man with the golden rule. You can depend on him at all times for help in meeting the operating problems caused by demands for ever-improved fuels. His personal knowledge is backed by the research and production facilities of one of the world's leading producers of catalysts. Call him anytime he can be of help to you...

Basic in catalyst chemistry

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, N. Y. 20, N. Y.

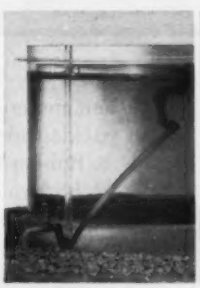
ON FLOATING ROOFS–



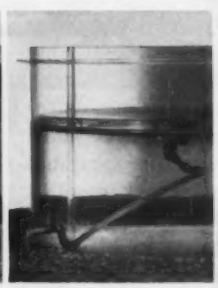
Chiksan Swivel Jointed Drain Lines team up strength + flexibility + endurance

The unlimited flexibility of Chiksan swivel joint equipped floating roof drains mean money saved on every tank. First, Chiksan drains cost less than rubber hose —and, you count their useful life in years instead of months. Chiksan swivel joints and lines easily withstand tank pressures —never kink to cause drain stoppage. Both lines and joints are available in many types of metals to meet specific liquid storage requirements.

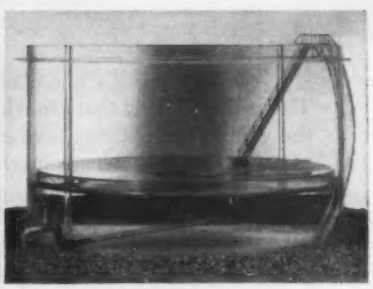
Plan now to include Chiksan drain lines in all new tank installations and in present lines that need replacement. For details, contact Chiksan or your nearby Chiksan field representative.



FULL TANK. Drain line flexes readily. Easily withstands tank pressures.



TWO THIRDS FULL. All metal line moves freely with the floating roof without danger of kinking.



TWO THIRDS EMPTY. Line folds compactly. Provides long years of trouble-free service.

CHIKSAN fmc

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

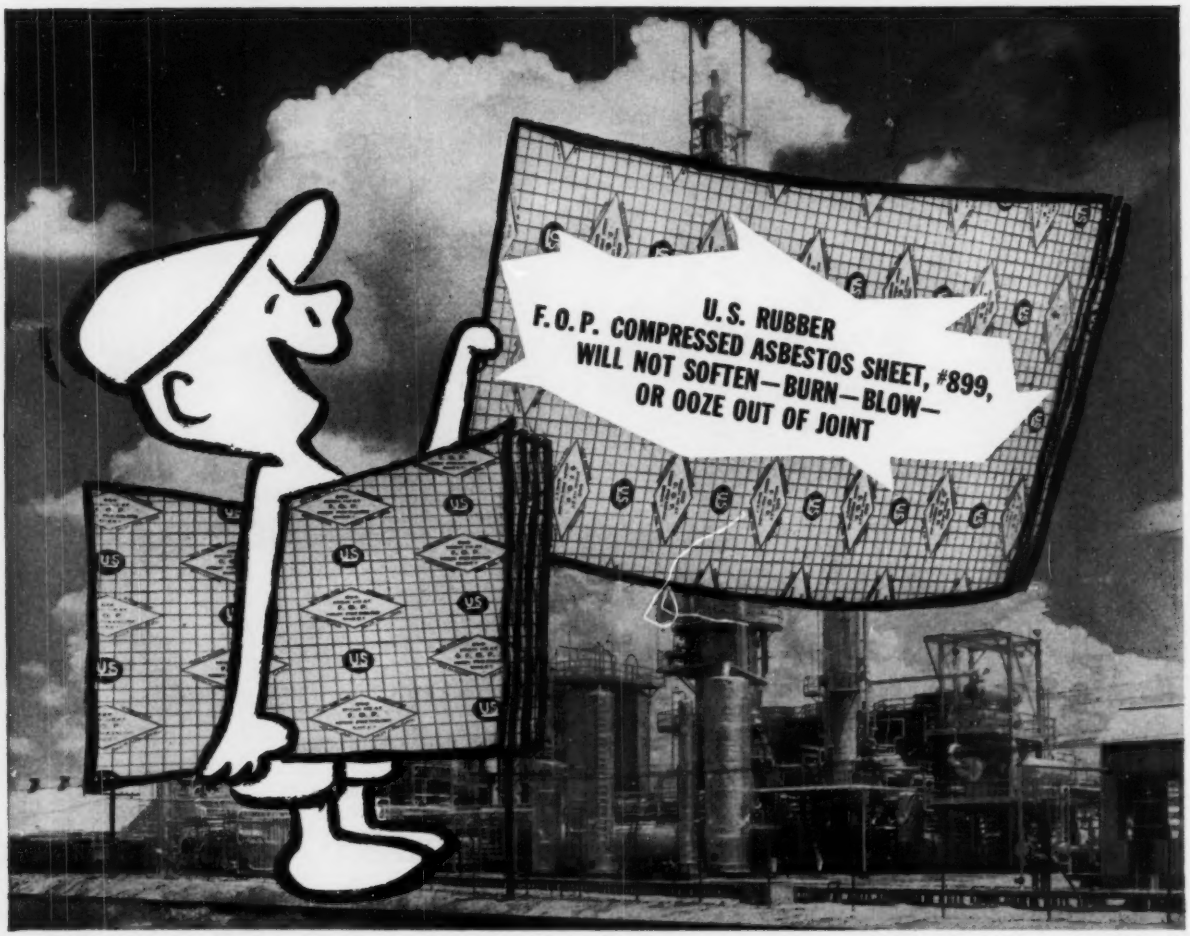
#60-49

CHIKSAN COMPANY—Brea, California • Chicago 5, Ill. • Newark 2, N. J. • Divisions: Chiksan International, Hamer Valves, Weco • Subsidiary: Chiksan of Canada Ltd.

For more data on advertised products, use Readers' Service Cards, last page.

US RUBBER PACKING

HOT NEWS for Hot Joints and Flanges



This is the packing that's making headlines where the going's the hottest . . . where flanges or joints must be packed against superheated or saturated steam, air, water, ammonia, gases, oil, gasoline and many chemicals.

U.S. Compressed Asbestos Sheet Packing was the first of its type developed particularly for refineries and chemical plants. It is made by a special process from selected long-fibre asbestos and bonded with exacting combinations of heat-resistant materials. Balanced construction makes this packing ideal for use as Still Head Gaskets.

U.S. Rubber Compressed Asbestos Sheet Packing can be furnished in a variety of constructions, each specially suited to a specific requirement. They are some of the hundreds of styles of U.S. Rubber Packing available.

• • •

When you think of rubber, think of your "U.S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.

Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

TOLAD® FUEL ADDITIVE

a NEW Tretolite product

IMPROVES FUEL "COLOR STABILITY" AND REDUCES RESIDUE AT LOWER COST

TOLAD* Fuel Additive formulations have been thoroughly tested in Tretolite laboratories and spot commercial applications for over two years. In test after test, TOLAD has improved fuel oil color stability, dispersed insoluble residue, and reduced sludging characteristics, and has done so at a lower cost than the commercial additive which it replaced.

FURNACE FUELS

TOLAD Fuel Additive enhances the salability of domestic furnace fuels in storage by inhibiting the formation of insoluble residue, preventing the formation of sludge and retarding color degradation.

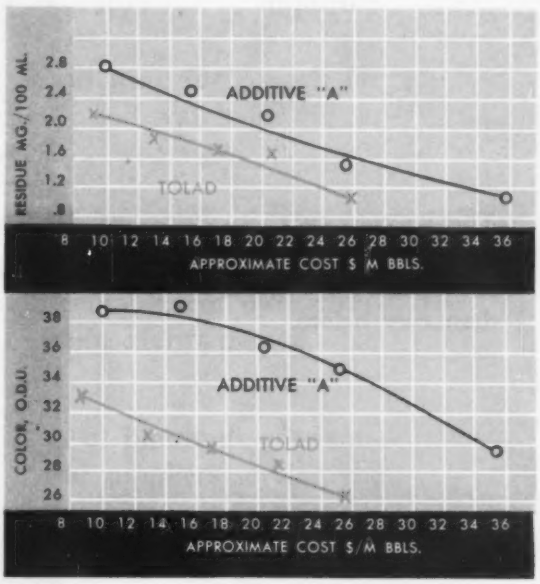
DIESEL FUELS

Diesel fuel sludge is the prime cause of plugging in fuel filters, injection systems and burner nozzles. TOLAD Fuel Additive improves the performance characteristics of diesel fuels by preventing the formation of sludge.

Whenever fuel deterioration is caused by long storage periods, TOLAD additive will *economically* help to maintain fuel quality and salability.

For complete information, ask your Tretolite refinery service engineer, or write to

The graphs illustrate TOLAD'S ability to improve color and residue characteristics of fuel in storage more economically. In these tests, a commercial furnace oil was subjected to a 12 week 110°F oven storage test. TOLAD was added to one sample, another commercial additive to the other. At every reading, TOLAD effected the desired color or residue characteristics at a lower per-barrel-cost.



*Registered Trademark, Petrolite Corporation

FA-60-2

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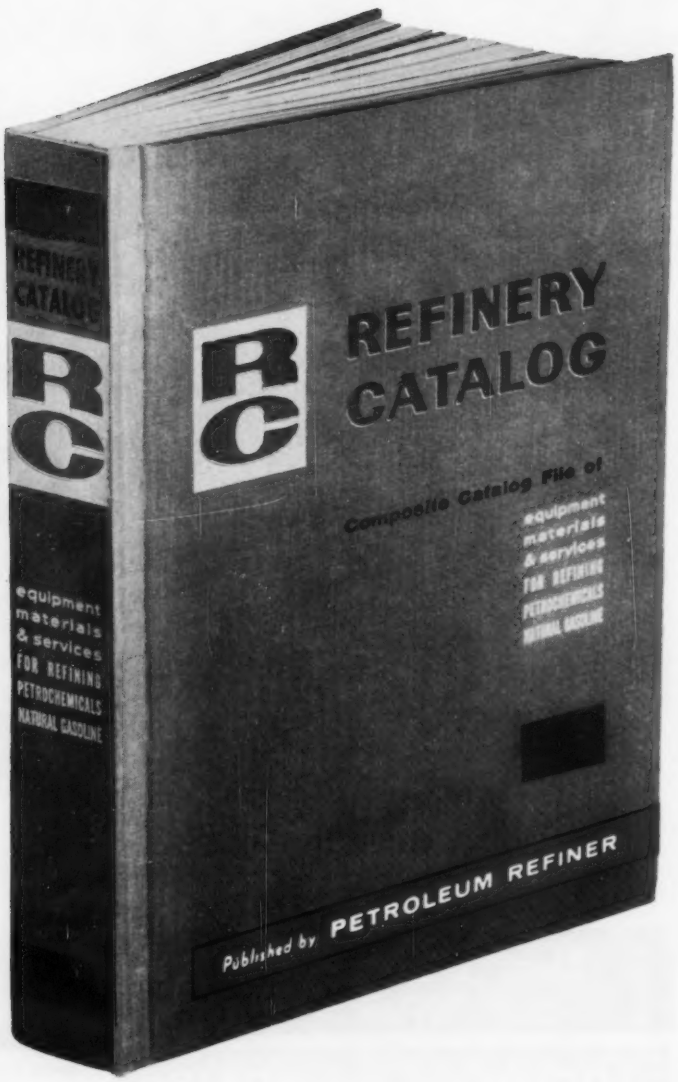

Included in the 1960 REFINERY CATALOG is a *new feature*—the 128-page A·S·A Refinery Piping Code

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– Natural Gasoline

– Petrochemicals

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The REFINERY CATALOG is an indispensable tool, more valuable and useful this year than ever before. Here's part of what you'll find in it!

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The REFINERY CATALOG

Published annually by PETROLEUM REFINER, Gulf Publishing Company

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For more data on advertised products, use Readers' Service Cards, last page.

"We deliver too"

What's so special about the huge fractionating tower shown here? It is one more example of how Sun Ship builds and delivers heavy industrial equipment on barges or sea-going vessels, with careful attention to such requirements as safety and on-time schedule.

Whether it's a fractionating tower or key structural part for industry, transporting big items by water or by rail is strictly routine for Sun Ship, for we build and deliver what's needed in many fields. If you have a machinery or heavy equipment problem, write to us about it.

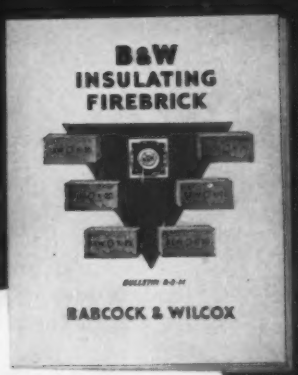
Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

Why B&W IFB for Oil Heater Linings ?

- Lightest weight
- Simplified construction
- High hot load strength
- Lower conductivity
- Lower heat storage
- Better process control



The light weight of B&W Insulating Firebrick provides savings in capital investment in several different ways. The light weight of B&W IFB permits thinner wall constructions of equivalent insulating value. These thinner, lighter walls mean real savings in structural steel and concrete. Construction is further simplified because B&W IFB's high hot load strength makes possible higher unsupported walls without deformation at furnace operating temperatures. In addition B&W IFB can be cut and shaped with ordinary wood working tools, simplifying field installation.

The light weight of B&W Insulating Firebrick also provides the greatest insulation. Thus, they save more fuel.

Light weight also means lower heat storage. B&W IFB protect you against burn-out of expensive alloy tubing in the event of forced shutdown. B&W IFB respond faster to changes in firing rate, too, assuring you of more positive process control.

**Write for Bulletin R-2-H giving more data on B&W Insulating Firebrick.*

B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

. . . in fluid catalytic cracking

DUCLONES® recover catalyst in world's leading refineries

Control of catalyst dust in reactors and regenerators of fluid catalytic cracking units is essential from the standpoints of operating efficiency, economy and air pollution control.

Type SDC Duclones and Ducon Dip-Leg Trickle Valves offer the ultimate in catalyst recovery systems. They have earned the enthusiastic approval of the world's leading refineries because of their consistently high efficiency, low pressure loss and long service life under high temperature and erosive conditions. Type SDC Duclones are available in a wide range of materials, sizes, plate thicknesses and multiple groupings. They can also be supplied lined with a refractory material.

Send today for Bulletins C-2058 and V-1458.

Photo courtesy Tidewater Oil Co.

DUCON — DUST CONTROL SYSTEMS AND EQUIPMENT

the name in DUst CONtrol

THE Ducon COMPANY INC.
147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK

Canadian Branch:
THE DUCON COMPANY of CANADA, Ltd.,
1131 Pettit St., BURLINGTON, ONTARIO

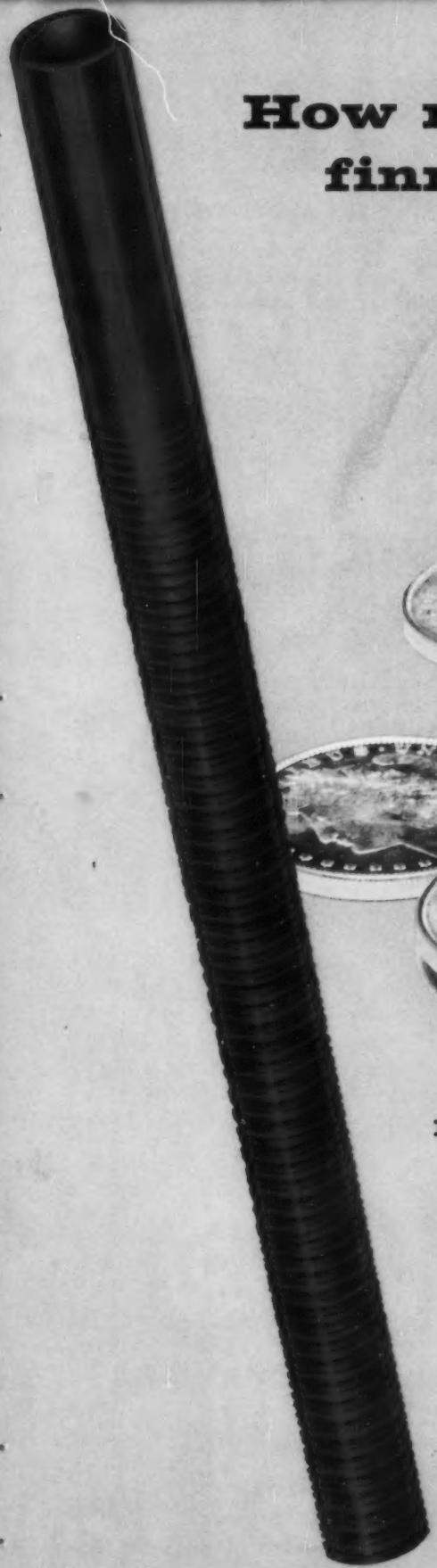
CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

For more data on advertised products, use Readers' Service Cards, last page.

How much does your finned tube dollar buy?

The answer is plenty—particularly when you buy Wolverine Trufin® Type S/T, the original, integrally finned tube.

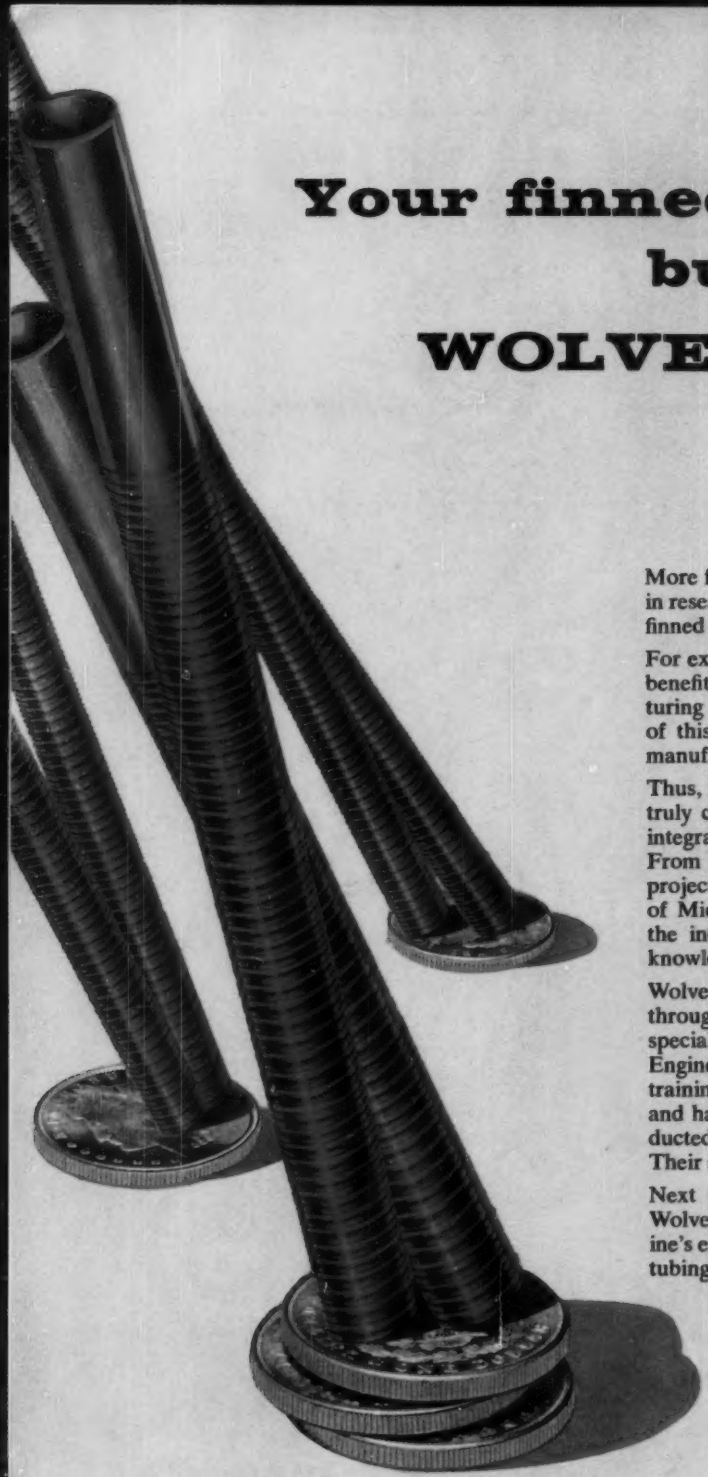
Wolverine Tube developed this type of tubing and over the past 20 years has brought Wolverine Trufin Type S/T to a high degree of perfection. Through constant research and testing plus actual "on-the-job" data gathered from countless installations, it has proved the many money-saving ways in which this extended-surface tubing can help you.



FOR EXAMPLE:

- Type S/T has more than 2½ times as much outside surface area as a comparable piece of plain tube
- More surface area means more BTU's per foot of tube thus requiring fewer tubes to transfer a given heat load
- Fewer tubes means smaller shells, headers, baffles, etc.
- Less weight of tube metal to transfer a given heat load
- Lighter units require less structural support
- Integral fins are unaffected by vibration, thermal shock, or pressure variations
- Interchangeable with plain tube
- Available in complete size ranges in copper, copper alloys, aluminum and steel

Ask your Wolverine sales representative for complete information about Wolverine Trufin Type S/T. Write, too, for a free copy of the Trufin Design and Cost Comparison Book.



Your finned tube dollar buys more from WOLVERINE TUBE

More for your money . . . in products . . . in services . . . in research and development . . . these are the things your finned tube dollar buys at Wolverine Tube.

For example, *only* from Wolverine Tube can you get the benefits of more than 20 years of finned tube manufacturing experience. Wolverine is the original producer of this type of tubing — for many years was the sole manufacturer.

Thus, it is *only* from Wolverine Tube that you can obtain truly competent guidance concerning the proper use of integrally finned tubing in heat transfer applications. From its own research facilities, and from research projects carried on in conjunction with the University of Michigan, Wolverine has, over the years, compiled the industry's most comprehensive file of finned tube knowledge.

Wolverine makes this information available to you through its literature and through its staff of heat transfer specialists. These men—members of the Wolverine Field Engineering Service — have all undergone intensive training in finned tube technology in Wolverine plants, and have completed a process heat transfer course conducted by Dr. Donald Q. Kern, Wolverine consultant. Their services are yours at any time—without obligation.

Next time you specify integrally finned tube, consult Wolverine Tube before placing your order. Let Wolverine's experience help you obtain maximum value for your tubing dollars.

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
GOODMAN LUMBER DIVISION
WOLVERINE TUBE DIVISION

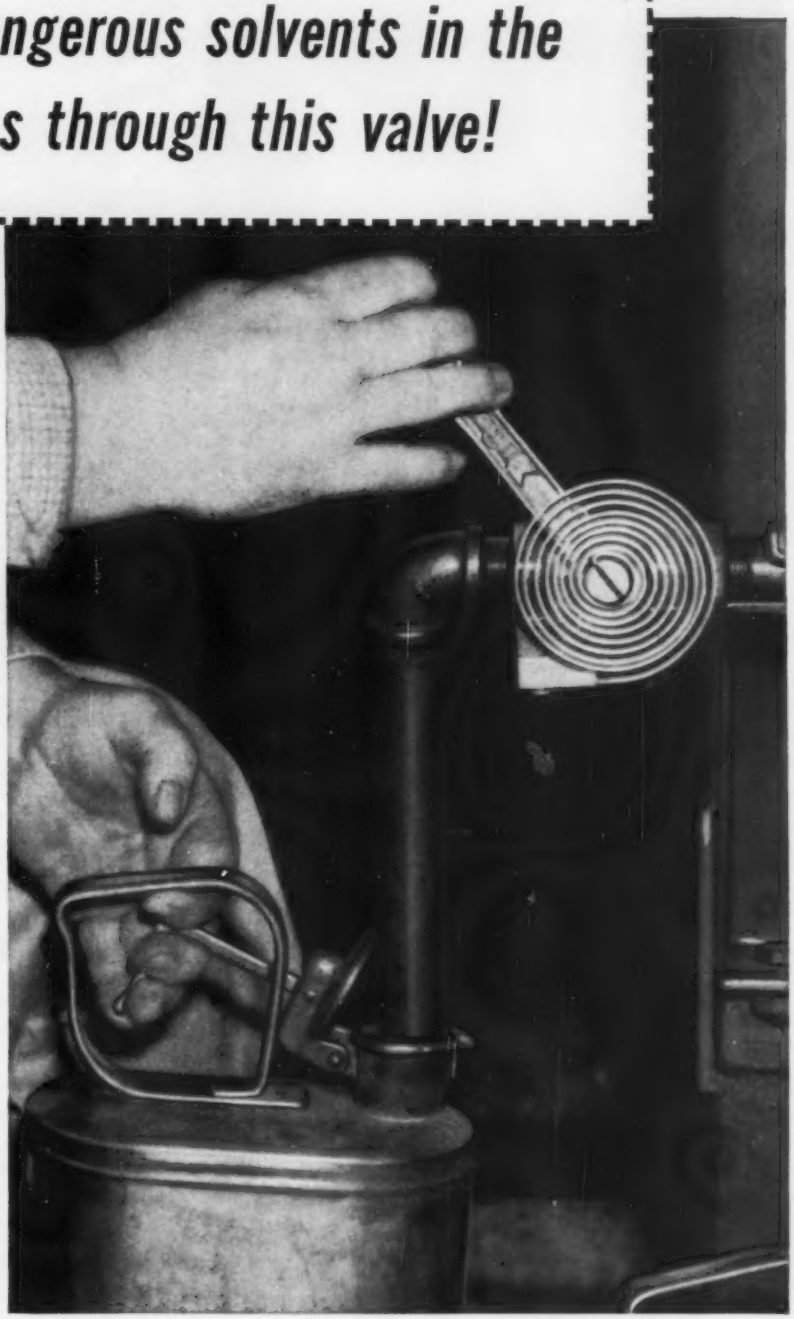
In Canada:
CALUMET & HECLA OF CANADA LIMITED
WOLVERINE TUBE DIVISION
CANADA VULCANIZER & EQUIPMENT CO. LTD.
UNIFIN TUBE DIVISION

WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17236 Southfield Road
Allen Park, Michigan
Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES.

The most dangerous solvents in the world pass through this valve!



But it's a *safe* passage. The ROCKWOOD ¾" (Fig. 802) Self-Closing Ball Valve is designed for *smooth, leakproof* handling of highly flammable liquids. A Rockwood Exclusive!

Take a typical installation at an experimental station of one of the nation's largest chemical companies. Here 36 different solvents, ranging from acetone to xylene, are dispensed from bulk containers. All types of self-closing valves were tried and evaluated for this critical job. None equalled ROCKWOOD for positive performance.

Unique ROCKWOOD Full Round Flow design holds turbulence to an absolute minimum — keeps static at a low level. Flash potential is negligible, greatly reducing fire hazard. In addition, the exclusive "*Spring Pressure* Compensation" keeps ball and seat in snug contact — assures leakproof, dripless shut-off, compensates for wear. Bronze valve body and Teflon trim resist corrosion. After 11 months and 103,200 open-and-shut cycles the company reports: trouble-free operation since installation.

Be as safe and sure with your solvent handling. Send coupon for complete details on the ROCKWOOD Self-Closing Ball Valve. Tested and listed by Underwriters' Laboratories, Inc.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

Distributors in all principal industrial areas

ROCKWOOD SPRINKLER COMPANY
A Division of the Gamewell Company
249 Harlow Street, Worcester 5, Massachusetts

Please send me complete details on the ROCKWOOD ¾" (Fig. 802) Self-Closing Ball Valve.

Name .....
Title .....
Company .....
Street .....
City ..... *Zone* ..... *State* .....

For more data on advertised products, use Readers' Service Cards, last page.

Fluid catalytic cracking unit, Toledo (Ohio) refinery, Standard Oil of Ohio

Refractory insulating concrete stops corrosion in this new FCC

In constructing the fluid catalytic cracking unit at Sohio's new Toledo refinery, corrosion resistance, abrasion resistance and insulation were built in right from the start. Refractory insulating concrete, bonded with LUMNITE calcium-aluminate cement, was used to line the regenerator, cyclones, stripper, catalyst and reactor transfer lines. Now on stream, these industrial concrete linings will resist severe erosion and abrasion caused by catalyst fines... resist attack by acid condensate... and provide insulation at high temperatures.

Installation of monolithic concrete linings is fast, easy, economical – whether cast in place, gunited or plastered. Concrete reaches service strength in 24 hours.

For added convenience, castables bonded with LUMNITE cement are available from leading manufacturers of refractories. These are packaged mixtures, ready for use with just the addition of water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N.Y.

"USS," "Atlas" and "Lumnite" are registered trademarks L-195

Universal Atlas Cement
Division of
United States Steel

OFFICES: Albany • Birmingham • Boston • Chicago • Dayton • Kansas City • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh • St. Louis • Waco

ORBIT ADDS VALVES TO INDUSTRIAL LINE

ORBIT CAST STEEL VALVES FOR HYDROGEN AND SIMILAR INDUSTRIAL GASES

As an addition to our line of valves handling hydrogen, similar industrial gases, and hydrocarbons, Orbit Cast Steel Valves have proven ideal for compressor, manifold, off-site and block valve installations.

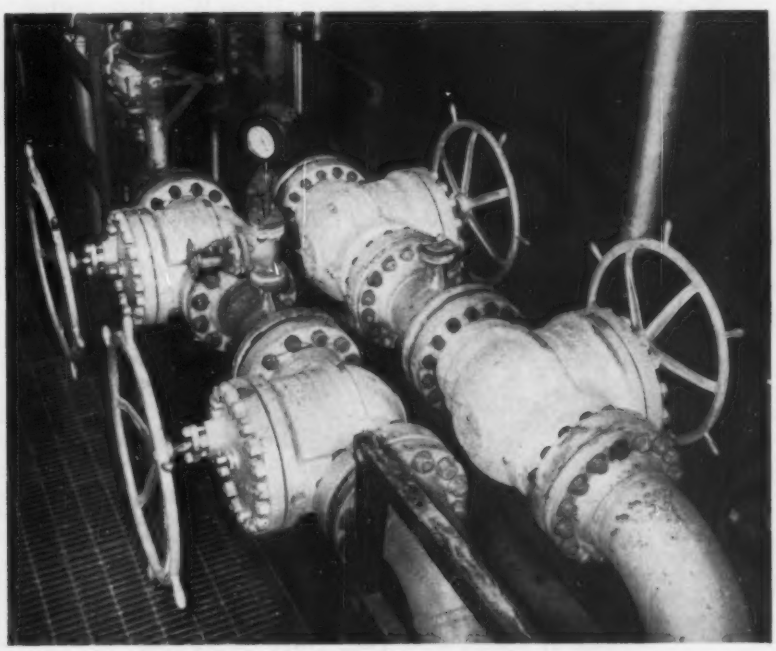
Orbit Cast Steel Carbon Trimmed Valves are particularly well suited to all the operating problems attendant to safest handling of industrial gases. These valves employ Orbit's friction-free seating principle already well known to users of our Forged Steel line of Industrial Valves.

All principal parts of Orbit Cast Steel Valves are made of steel castings and steel drop forgings, with bonnet bolted to body. A stem locking device permits valve to be locked open or closed. 2½ to 3 turns opens or closes valve.

SIZES: 5", 6", 8" & 10" *Series 300 and 400 Flanges
5", 6" & 8" *Series 600 Flanges
5" & 6" *Series 900 Flanges

Above sizes except 10" available in Screwed Ends.
*End to End Dimensions are Special.

ORBIT CAST STEEL VALVES INSTALLED ON HYDROGEN GAS COMPRESSOR MANIFOLDS IN A LARGE OHIO REFINERY.



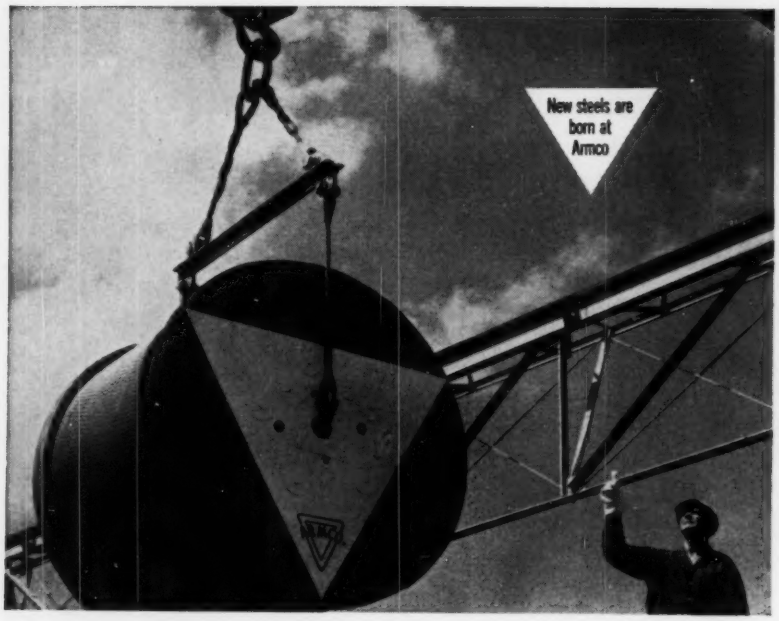
ORBIT VALVES ®

Available through your favorite supply house. Or, write Orbit today for complete information and specifications.

ORBIT VALVE COMPANY

P. O. BOX 699, TULSA, OKLAHOMA
PHONE LUTHER 4-4761, TWX TU 925

For more data on advertised products, use Readers' Service Cards, last page.



Tuffy is famous for "firsts"

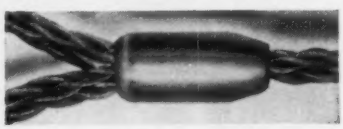
It's been that way for more than 30 years. Union Wire Rope started with an idea: that wire rope making should be a specialized field. And that the many different uses of wire rope needed specialized designs and constructions.

From that specialization have come many Union-developed "firsts." One of the most famous is the Tuffy line of patented 9-part machine-braided slings. The combination of extra strength and extra flexibility give you the ultimate in sling construction.

What does it mean to you as a sling user? Longer service life. Dependable operation. Greater safety. And ultimately the lowest cost sling you can buy, because of the extra service and efficiency.

Tuffy gives you these extras at no extra cost

Exclusive 9-part machine-braided fabric gives flexibility never found in any other sling. It's next to impossible to kink. If a kink should occur, it can be smoothed out easily leaving no damage.



Pressed-on metal ferrule gives the eye splice 100% of fabric strength. Applied under tremendous hydraulic pressure, it is also streamlined to eliminate projections and snags that might injure hands.

Get in Touch with Your Tuffy Distributor

Whether your sling jobs call for machine-braided Tuffy slings, or the new line of Union 6- and 8-part hand-braided slings, your Tuffy distributor is ready with the right item. Look him up in the Yellow Pages.

Tuffy® Tips
—on safe use of
Slings and Hoist Lines

Hoists vs. Hernia

About 75% of one manufacturer's compensation claims were connected with hernia — a common hazard in heavy lifting. Hernia claims average around $750. No need to stress the need for hoists instead of muscles for lifting tasks.

Hoist and Sling Safety Rules

1. Use a proper size hoist—not human backs and muscles—for every heavy lifting job.
2. Never use load chains as slings. Chain links break easily after distortion.
3. Use the sling that's right for the job. There's a Tuffy Sling for every purpose.
4. When loading slings with more than two legs: load a 3-legged sling as though it had 2½ legs; load a 4-legged sling as though it had 3 legs.

Use Tuffy Hoist Line

Tuffy Hoist Line and Tuffy Slings are the ideal team for efficient, safe hoisting at lowest long-run cost. The extra strength, toughness and service life we build into the Tuffys results in ultimate low cost.

FREE!
New Tuffy Sling Handbook

All about slings from A to Z, including types, dimensions and rated loads. Address **Union Wire Rope Corporation, 2284 Manchester Ave., Kansas City 26, Missouri.** Specialists in high carbon wire, wire rope, braided wire fabric, and stress relieved wire and strand.

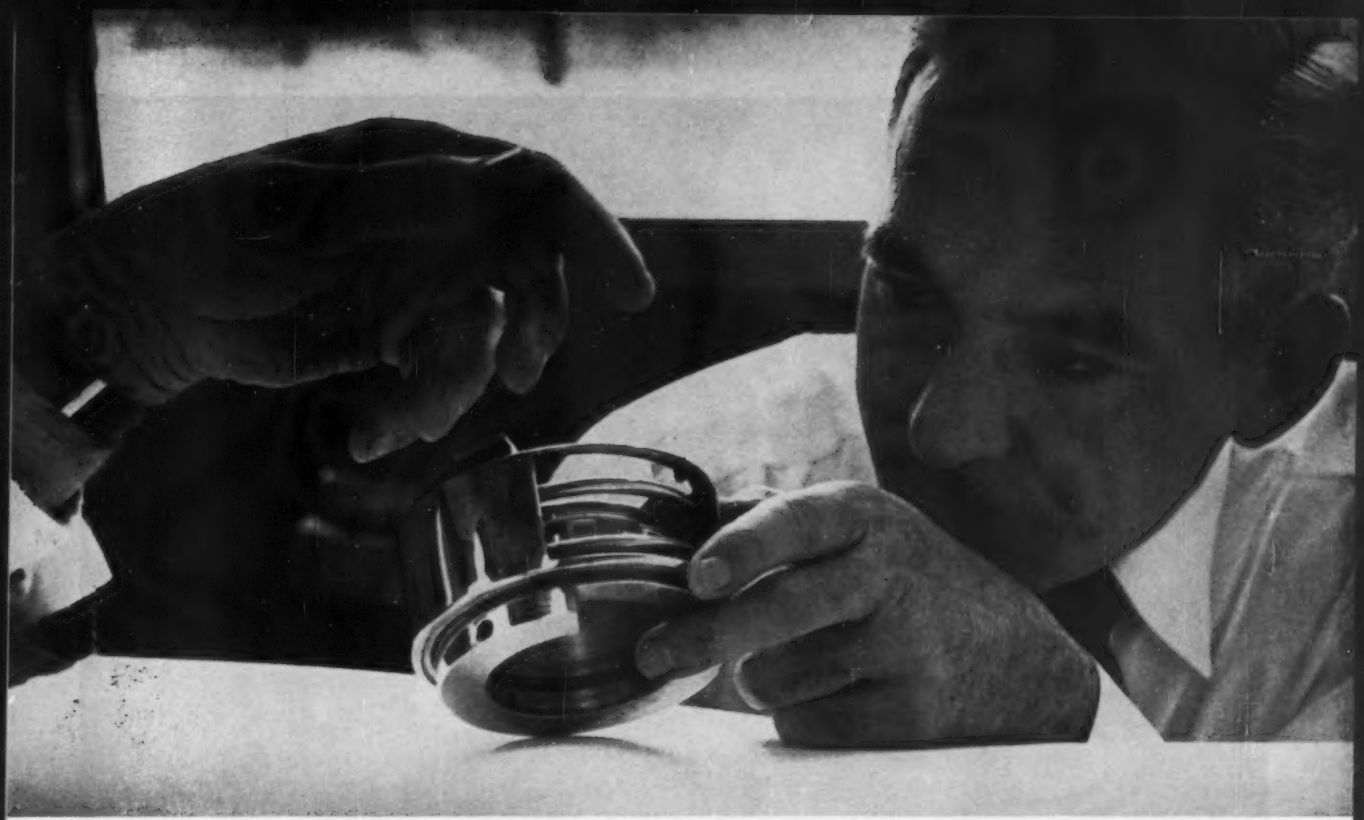
2

UNION Wire Rope

Subsidiary of ARMCO STEEL CORPORATION

OTHER SUBSIDIARIES AND DIVISIONS: Armco Division • Sheffield Division • The National Supply Company
Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Southwest Steel Products

For more data on advertised products, use Readers' Service Cards, last page.



Cut mixer maintenance cost as much as 60%

. . . specify LIGHTNIN Mixers with this leakproof seal

This mechanical seal can save you up to 60% of what you'd expect to spend on annual upkeep of a side-entering mixer on a big blending tank.

It *never* needs adjustment—runs for years without attention. It eliminates all the costly maintenance of a packed stuffing box.

At the same time, it positively stops troublesome drip, drip, drip—prevents waste of product and gives you clean, safe housekeeping around the tank.

And, when the seal finally does wear out, it's easy to replace—just a simple cartridge unit. One man can do the job easily and quickly, even with a full head of liquid in the tank.

There are no loose seal parts you have to assemble—no delicate adjustments to make. The cartridge is easy to stock as a spare. Or you can get a new one from MIXCO in a hurry when you need it. The seal is made in all sizes, and in materials to suit the simplest or toughest mixing conditions.

Biggest surprise of all is the price. A seal-equipped LIGHTNIN Mixer costs only a few dollars more than one equipped with a packed stuffing box.

Refiners everywhere are saving thousands of dollars yearly on mixer maintenance with this exclusive LIGHTNIN Mixer feature. To learn how inexpensively *you* can use it to build low-cost upkeep into your big blending tanks, call in your LIGHTNIN Mixer representative today. He's listed in Refinery Catalog. Or write us direct.

For simplest possible maintenance, you can get LIGHTNIN Side Entering Mixers in a wide choice of corrosion-resistant materials, with gear drive or V-belt drive, and with mechanical seals or stuffing boxes to meet every service condition.

"Lightnin® Mixers"

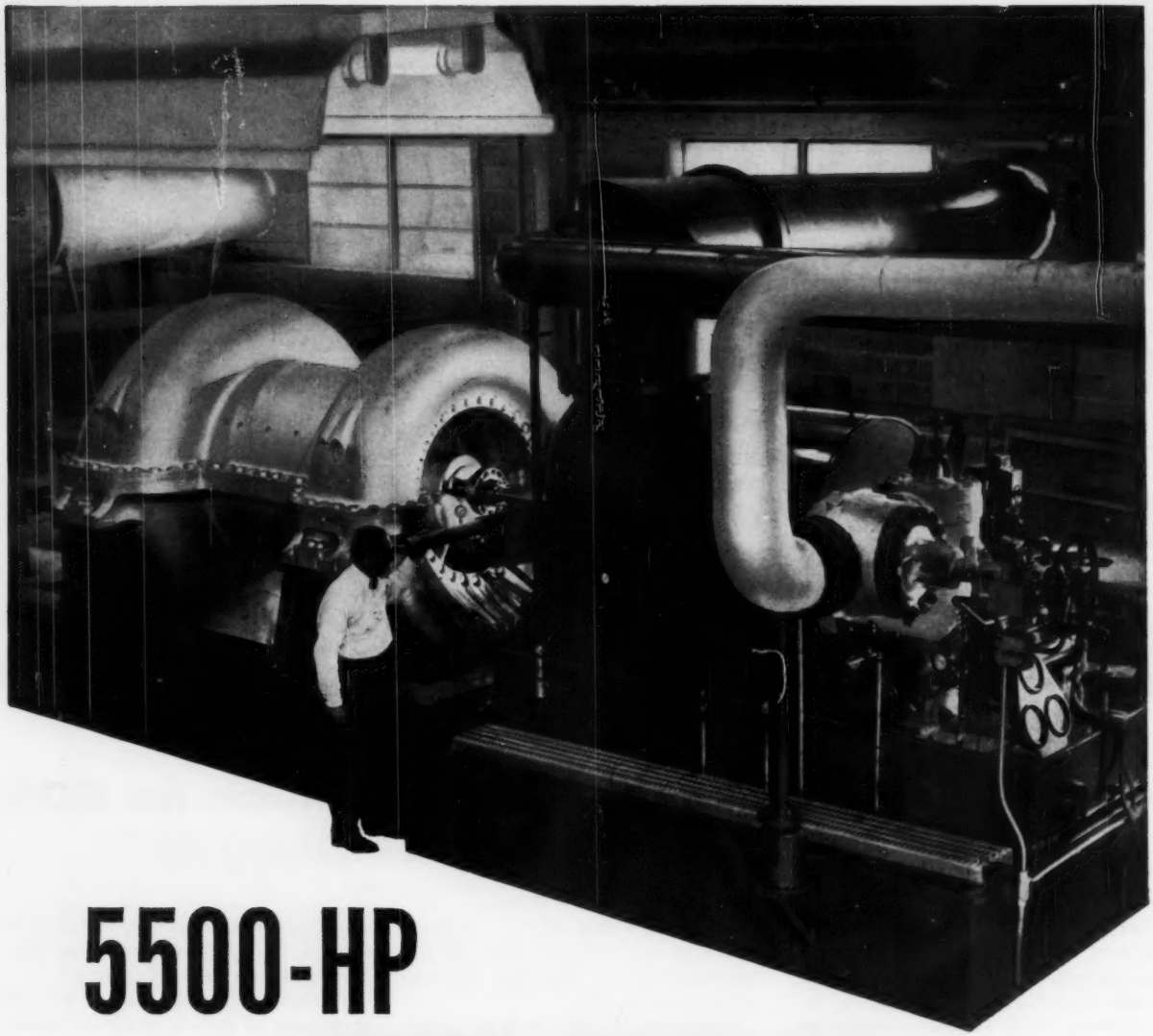
MIXCO fluid mixing specialists

- ☐ Send us the cost-cutting facts on LIGHTNIN Rotary Mechanical Seals—Bulletin B-111. We'd also like catalog information on these LIGHTNIN Mixers:
- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering propeller types: ¼ to 3 HP (B-103)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Data sheet for figuring mixer requirements (B-107)

Check, clip and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 164-c Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.



5500-HP TERRY TURBINE

plays an important role in compressor testing at Joy

Joy Manufacturing Company puts Terry high-speed turbine reliability to good use in its development facility at Buffalo, New York. This 5500-hp multistage turbine is used for testing centrifugal and axial-flow compressors. It provides speeds up to 9,000 rpm.

The long, trouble-free life of Terry high-speed turbines stems from two sources: (1) more than 50 years of successful experience in making turbine drives *exclusively*, (2) a willingness to build *something extra* into each machine to assure its reliability.

There's a reliable Terry turbine for you in sizes up to 6000 hp. In special cases higher outputs can be supplied.

For more information about Terry multistage turbines, ask for a copy of bulletin S-146.

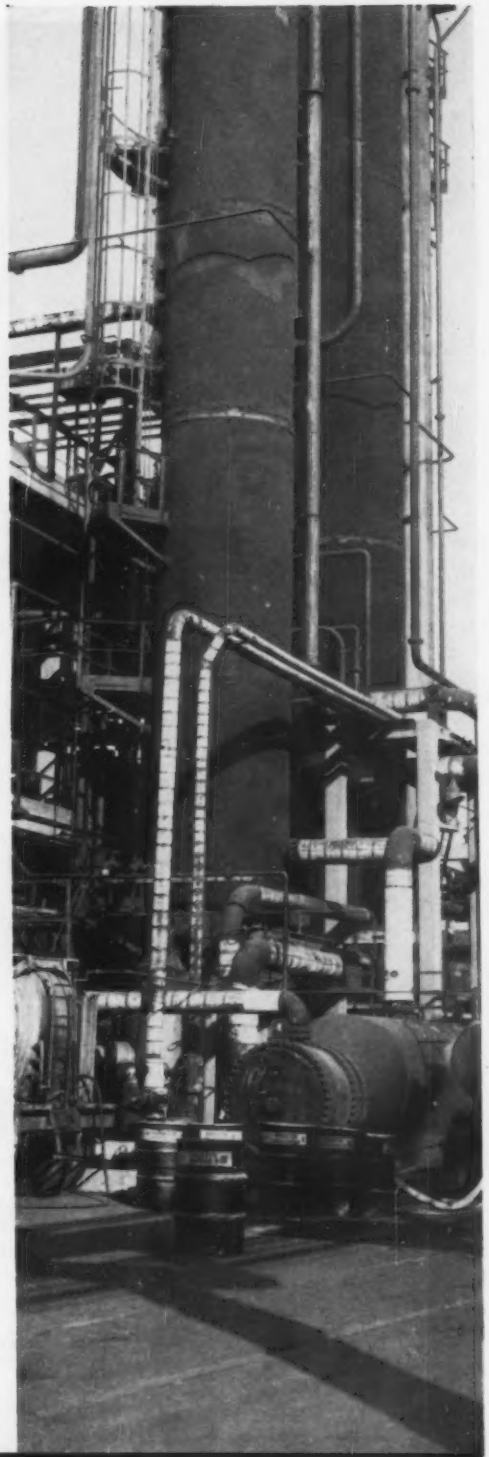
TERRY

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

TT-1215

Oakite ECP
engineered cleaning program

saves 3 days downtime with 1 drum of cleaner



Severe vibrations threatened to tear up a 30,000 cfm air blower before it reached even half-speed. Diagnosis: an oil leak from the previous run had probably carbonized on hidden areas of the impeller. A cat cracker, just getting back on-stream, was threatened with another three days downtime if the blower had to be taken apart.

Remedy: call the Oakite man. (An Oakite ECP includes *technical service.*)

The Oakite man proposed pumping a mixture of Oakite 8, water and steam into the blower—to clean it in-place. A few hours later refinery was able to put 160,000 lbs. of air per hour into their converter (the highest rate ever). This meant they were able to crack higher and increase gasoline, propane and butane yields. Downtime was eliminated; three day production loss (33,000 bbls.) avoided. ALL WITH ONE DRUM OF MATERIAL!!

WHAT IS OAKITE "ECP? ECP stands for Engineered Cleaning Program. It's a program of periodic chemical cleaning tailored for your refinery. It considers your equipment, conditions and through-put—itemizes your problems and the materials and methods to solve them.

But an ECP is much more than a standard program. It's the eagerness of the Oakite man to make *your* emergencies *his* concern. It's his experience in refinery cleaning, backed by the finest cleaning research facilities in the world, supported by materials *guaranteed* to work. Send for details. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

OAKITE
over 50 Est. 1909 SCIENCE
years' leadership in industrial cleaning

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Oakite ECP
your economy key

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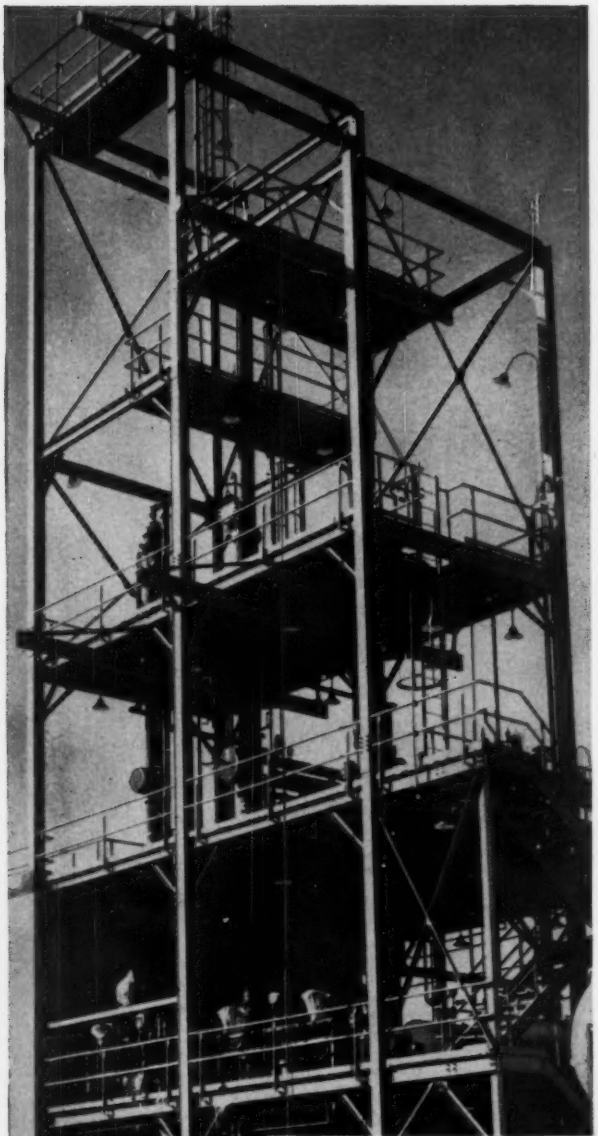


New

CHROMOMAX*

helps Pennsalt boost product quality

For more than six months, Pennsalt Chemicals Corporation at Calvert City, Ky. has based control of its Isotron plant on Chromomax data. Component concentrations as low as 0.01% are detected and measured by this highly sensitive L&N Chromomax Gas Chromatography Analyzer. It enables Pennsalt's operator to monitor impurity levels every 10 minutes . . . to make any necessary control adjustments. The result: the refrigerants and aerosol propellents produced have a purity of more than 99%.

Pennsalt also relies on Chromomax because it's dependable . . . needs only routine maintenance . . . requires simply a weekly check against a standard sample. The instrument maintenance group finds that programming cycles are easy to reset after a process changeover. These benefits confirm Pennsalt's policy of getting the best instrument for the application.

If you, too, have a process stream measuring problem, let L&N's versatile Chromomax Analyzer solve it . . . economically . . . dependably. If required, your Chromomax can be equipped with dual column switching or electronic integration.

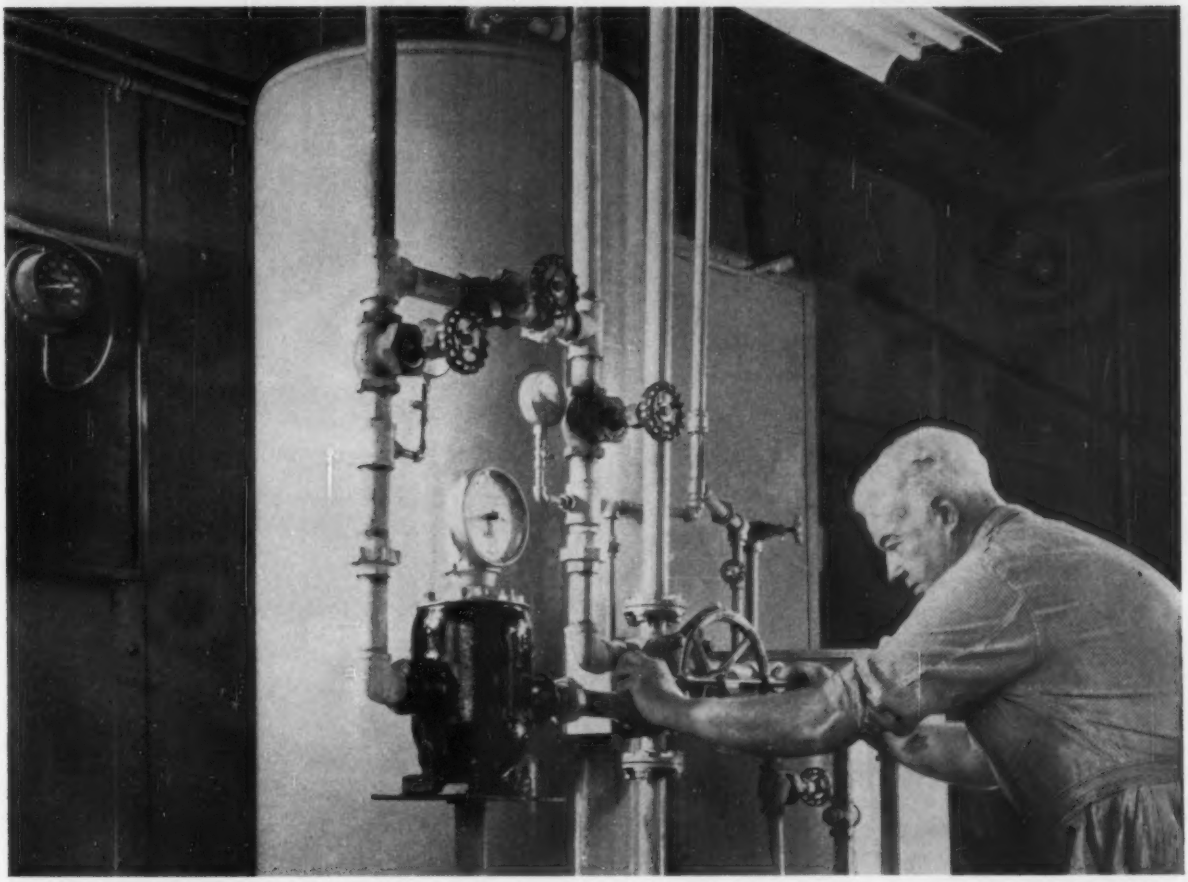
Check with your nearest L&N Office for application details or write to Leeds & Northrup Company, 4923 Stenton Ave., Phila. 44, Pa. for information.

**Trademark*

In the control room of Pennsalt's Isotron plant, a process operator checks component variations on a Chromomax Analyzer as a guide to resetting control points.

LEEDS NORTHRUP
Instruments Automatic Controls • Furnaces

FLUIDICS* AT WORK



NEW FROM PERMUTIT!* Complete Line All Purpose Model BD Economy Softeners

Permutit® Model BD Softeners answer industry's demand for more and more soft water at lower cost. Taking advantage of new design advancements and standardized mass produced components, Model BD Softeners now make Permutit quality available in a complete line, ready for prompt delivery from stock at economy prices.

BD Softeners contain only high capacity Permutit Q Resin. Absence of subfill eliminates possibility of upsetting bed, makes installation simpler, less expensive. Exclusive double-dish underdrain is shipped completely assembled, further simplifies installation. Standard valve is the famous Permutit Multiport® type.

Permutit Model BD Softeners are available in the following sizes and capacities:

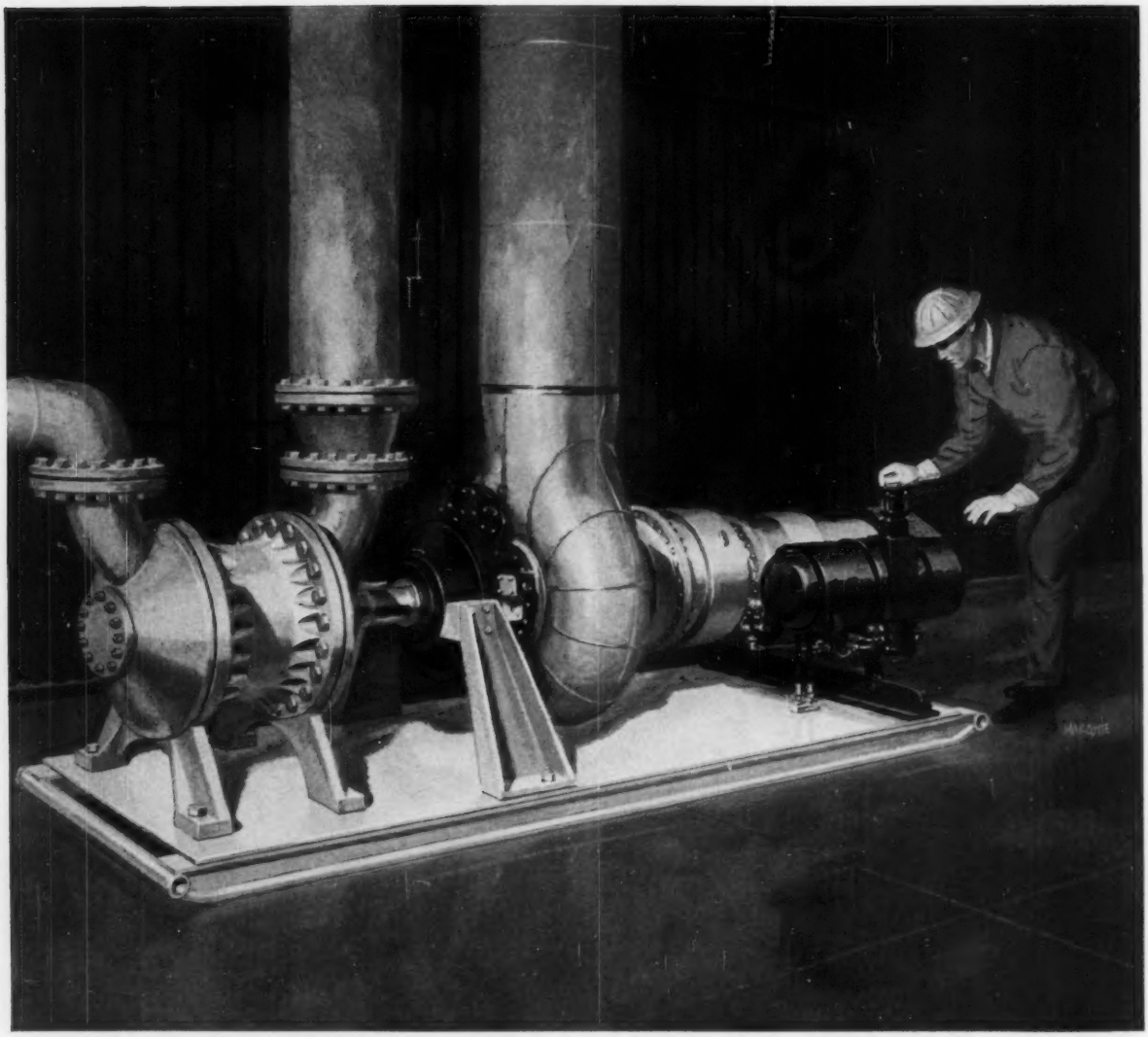
Shell Diam.	Straight Ht.	Flow Rate Average	Softening Capacity
30″	6′	40 gpm	510 Kgr
36″	6′	56 gpm	750 Kgr
42″	6′	77 gpm	1020 Kgr
48″	6′	100 gpm	1380 Kgr

For specifications and complete information, write to our Permutit Division, Department PR-30, 50 West 44th Street, New York 36, New York.

PFAUDLER PERMUTIT INC.
Specialists in FLUIDICS . . . the science of fluid processes

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

For more data on advertised products, use Readers' Service Cards, last page.



UNIQUE NEW COMPRESSOR

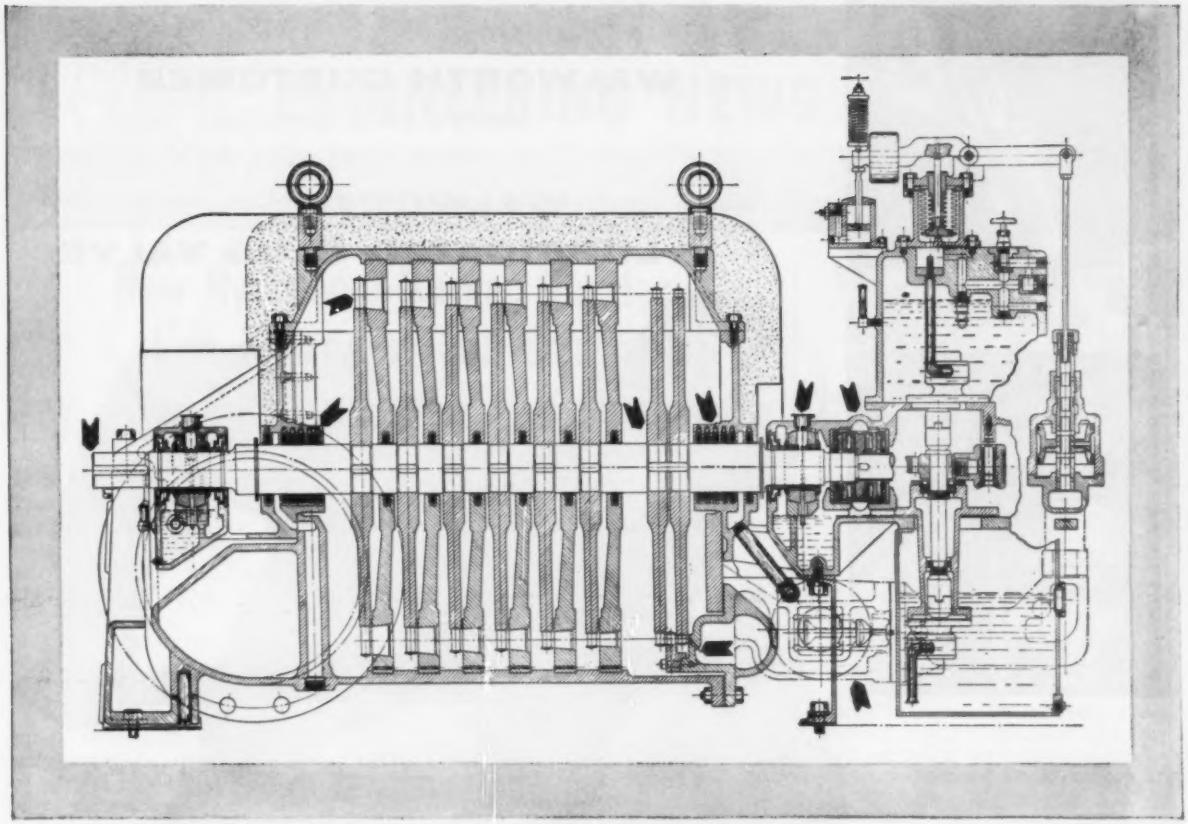
Solar industrial gas turbine-driven centrifugal compressor offers advantages found in no other type

SOLAR'S LIGHTWEIGHT centrifugal compressors incorporate unique new features for applications in the low-volume range. They operate in a range of flows and pressures new to centrifugal equipment. Interchangeable compressor wheels and other parts permit quick, low-cost field changes to accommodate new flow and pressure requirements. Ideal for main pipeline stations as well as field use, they can be started or shut down in seconds—even by remote control—and are ideal for unattended operation.

Designed to match the high rotating speeds of Solar gas turbine drivers, Solar's new compressor packages are small and lightweight (a fraction of the weight of conventional piston-driven units). They require only the lightest foundations. Maintenance is simple. Easy portability allows periodic inspection at a central shop.

A new illustrated brochure describes in detail Solar centrifugal gas compressors. Write for it to Dept. G-196, Solar Aircraft Company, San Diego 12, California.

SOLAR
AIRCRAFT COMPANY



ANOTHER INSIDE STORY OF THE UNIVERSAL ACCEPTANCE OF MURRAY MULTI-STAGE TURBINES IN THE MECHANICAL DRIVE FIELD

- Husky accurately machined shaft.
- Discs shrunk and keyed in place.
- Stainless steel nozzles and blading throughout.
- Spherical seated sleeve bearings.
- Kingsbury thrust bearing.
- Center line support.
- Carbon ring gland seals.
- Double seated balanced governor valve – stellited.
- Choice of speed governors from simple mechanical type to precision oil relay.
- Bolt type overspeed trip governor.
- Steam conditions to 600 PSIG and 750°F.
- Condensing or non-condensing.

Our nearest representative will gladly help you solve your mechanical drive turbine requirements. Just write to Murray Iron Works Company, Burlington, Iowa, for his name.

Murray
TURBINES

MURRAY IRON WORKS COMPANY • BURLINGTON, IOWA
Builders of Steam Power Equipment for Nearly a Century

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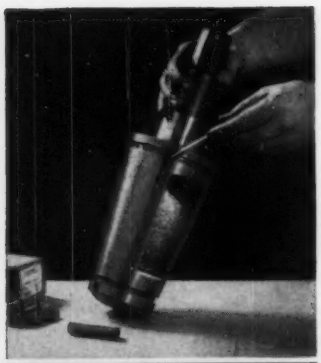
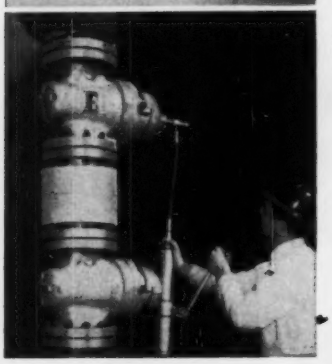
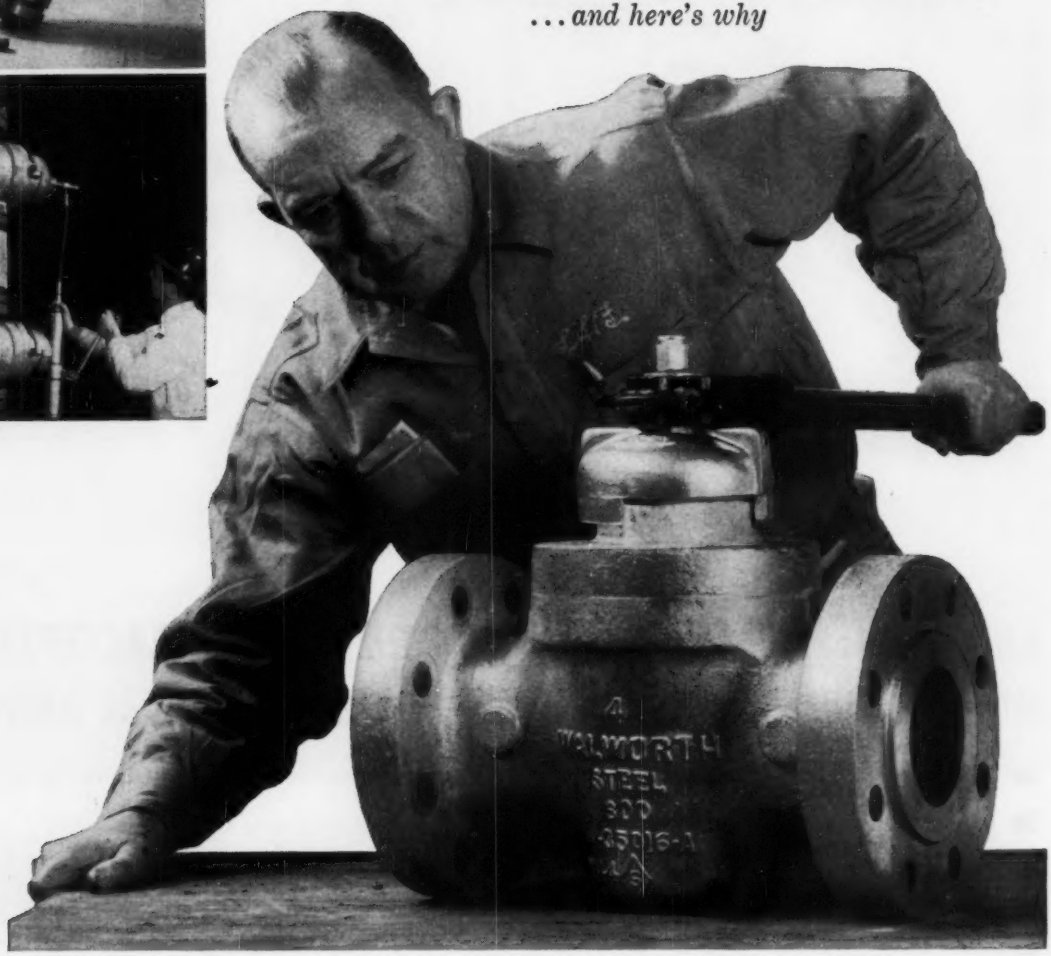




the **WALWORTH CUSTOMER**
wants a quick operating,
sure, tight valve. He chooses a

WALWORTH
LUBRICATED PLUG VALVE
. . . and here's why



When the Walworth Customer has to decide on a valve that will close fast and easily, he wants to know HOW fast . . . HOW easily. Tight closure? Of course. But can the valve be serviced under pressure? Yes. Still, he tries one himself.

In the Walworth Lubricated Plug Valve he finds 100% tight closure because it is lubricant-sealed against leakage. He finds it opens or closes with a quarter turn. Then, and only then, he's ready to buy. If that's the way you like to buy valves, we want you, too, for a Walworth Customer. For details on all types and ratings of Walworth Lubricated Plug Valves, ask your Walworth Distributor.

Or write **WALWORTH** *750 Third Avenue, New York 17, N. Y.*
DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. M&H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING & WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.

NATIONAL AIROIL BURNER

ENGINEERING NEWS

NATIONAL AIROIL BURNER CO., INC. • 1284 E. Sedgley Ave. • Philadelphia 34, Pa.

You may wish to check certain items in this advertisement and forward to those concerned in your company.

ROUTE TO:

_____

_____

_____

_____

New Hydrocool Burner Nozzles Fire Hydrogen Rich Gas in Any Type Furnace Safely . . . Economically

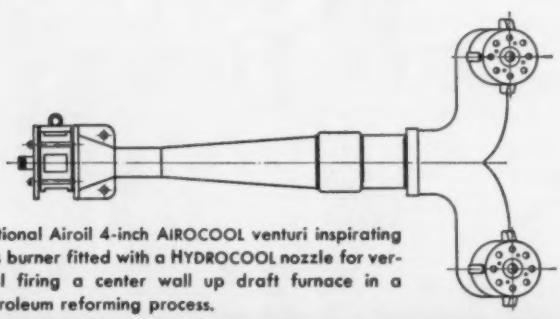
Here's a new gas burner nozzle that provides safer operation with hydrogen or hydrogen rich gas fuels in various furnaces; also assures efficient burning of any other gas including the natural or by-product types.

The HYDROCOOL Gas Burner Nozzle will produce a short, hot, stable flame with a high turn-down ratio, and with extremely low excess air in the nozzle. This nozzle is an excellent replacement for other makes of nozzles where the previously used high density gas has now been replaced by hydrogen.

In the HYDROCOOL Nozzle *one main* port and a circle of eight supplementary ports collectively have the same area and consequently the same mixture velocity as the single port of a conventional nozzle. However, on the HYDROCOOL Nozzle, its main port has 50% of the total area required. The remaining 50% required area is divided equally between the 8 to 16 supplementary ports. This reduction in individual areas is a most effective means for retarding "flash-backs."

National Airoil HYDROCOOL Nozzles are available in I.P.T. sizes of 3", 4", 6" and 8". They can be a part of combination gas and oil burner units or where necessary, may be machined to produce a shorter flaring gas flame as compared with other nozzles.

Bulletin 57 contains engineering details and other data on HYDROCOOL Nozzles. Write for a free copy today.



National Airoil 4-inch AIROCOOL venturi inspirating gas burner fitted with a HYDROCOOL nozzle for vertical firing a center wall up draft furnace in a petroleum reforming process.

National Airoil 4-inch AIROCOOL venturi inspirating burner having finger control register for primary air. Also equipped with twin 3-inch HYDROCOOL nozzles for firing against a radiating wall in center wall up draft heaters.

Why Conventional Nozzles are Unsatisfactory for Firing Hydrogen Gas

Conventional flame retention nozzles for venturi inspirating gas burners (Fig. 1) are designed primarily for use with natural gas or those gases of similar composition, heating values and molecular weights.

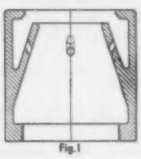


Fig. 1

In firing hydrogen, however, considerable difficulty is encountered, causing mixture "flash-back" to produce an initial explosion and/or continuous burning back within the venturi tube.

Further difficulty is encountered when plant personnel endeavor to correct the condition by disproportionately reducing the primary air to the venturi. The effect of this excessive adjustment is to lengthen the gas flames and risk secondary combustion around the tubes of the convection section in petroleum heaters. These longer and less concentrated furnace flames tend to reduce the heat absorbed by the wall radiant tubes. They also cause inefficient fuel performance by requiring a higher excess air that increases both the stack gas temperature and the fuel consumption.

In some center wall up draft petroleum heaters, the conventional nozzles are burned so badly that gas flames frequently take place in the combustion air ducts under the furnace floor. Photos A and B show the remains of two conventional nozzles that deteriorated after only a few months' duty. With the average center wall up draft heater, it is an expensive undertaking to remove the burners, renew the nozzles and replace the burners. The cost in time and labor greatly exceed the purchase price of the nozzles themselves.

A B

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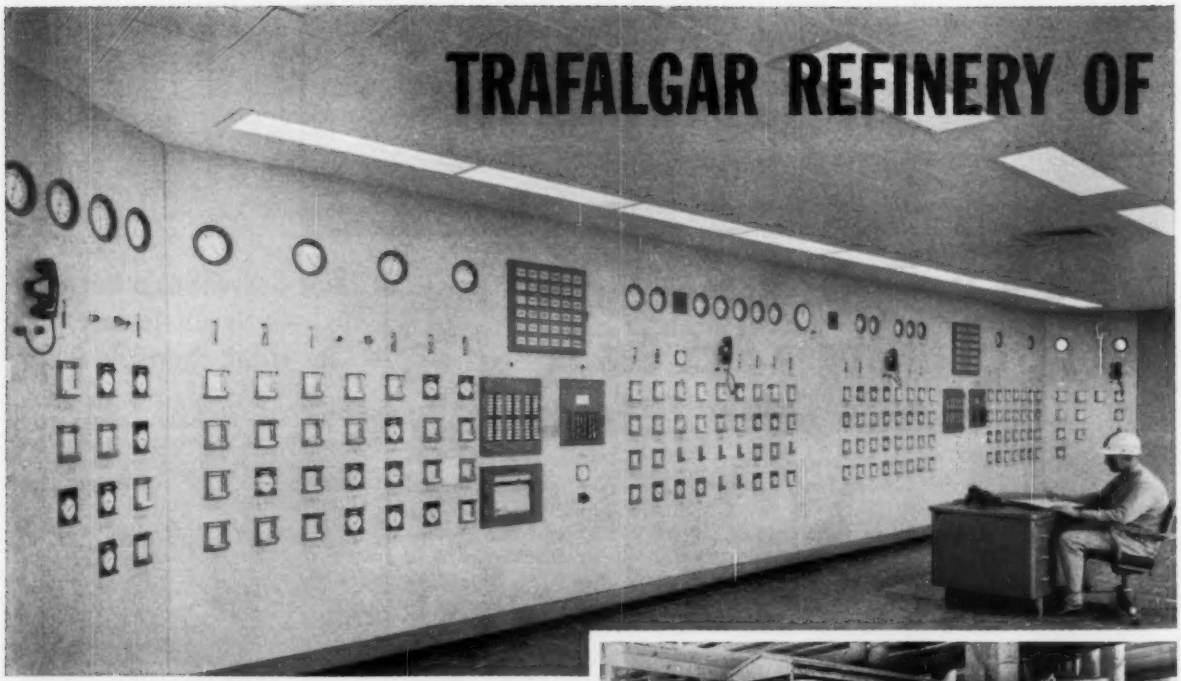
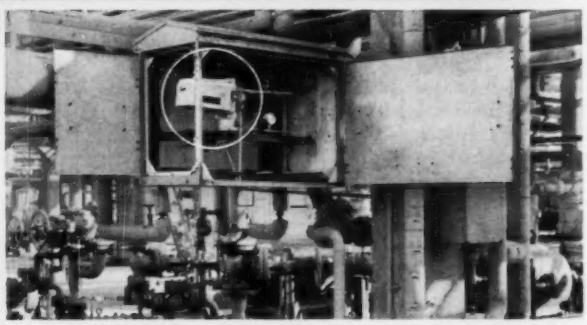
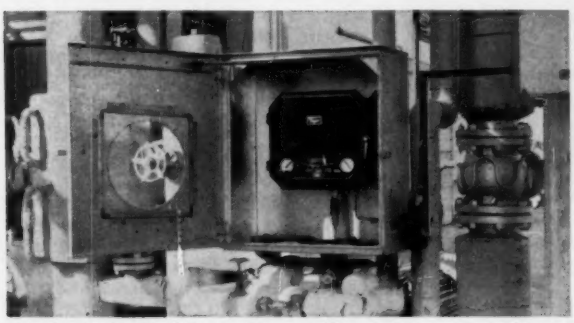


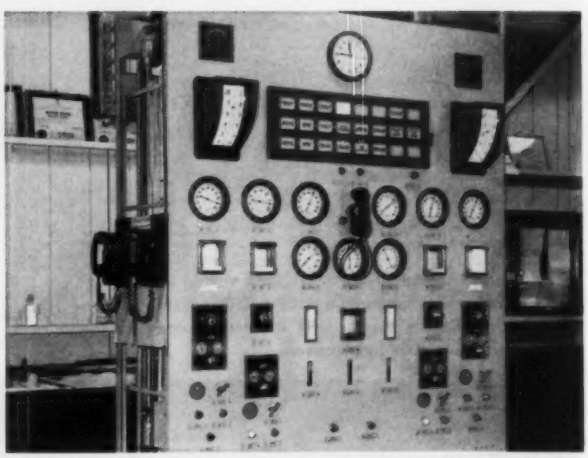
Centralized Taylor Control Panel for the four main process units at Trafalgar: (1) Crude Fractionation, (2) Catalytic Cracking, (3) Gas Plant, (4) Catalytic Reforming.



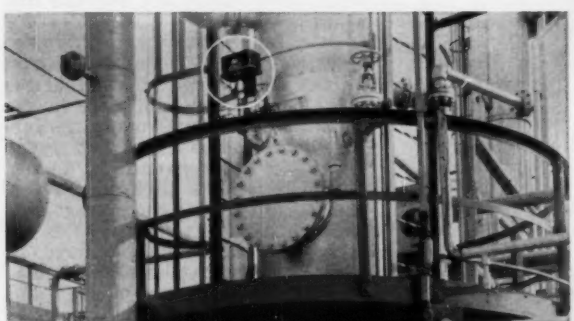
Taylor 333RD Differential Pressure Transmitters used on Catalytic Gasoline Splitter Feed.



Taylor Boiler Feed Water Pressure Transmitters — one of many applications.



Utility control panel for power plant at the Trafalgar refinery.



TRANSAIRE® Temperature Transmitter — installed on Catalytic Gasoline Splitter column bottoms.

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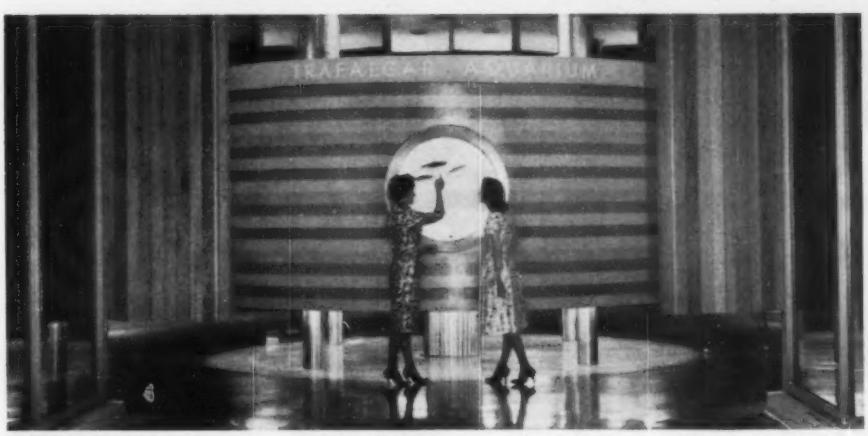
Lake Ontario fish thrive in Trafalgar Refinery's waste water.



This 6,000 gallon aquarium is supplied with effluent water actually more pure than originally drawn from the lake. The water treatment plant is reputed to be the most efficient ever installed in a refinery.

The Taylor control panel for the Trafalgar water treatment plant.

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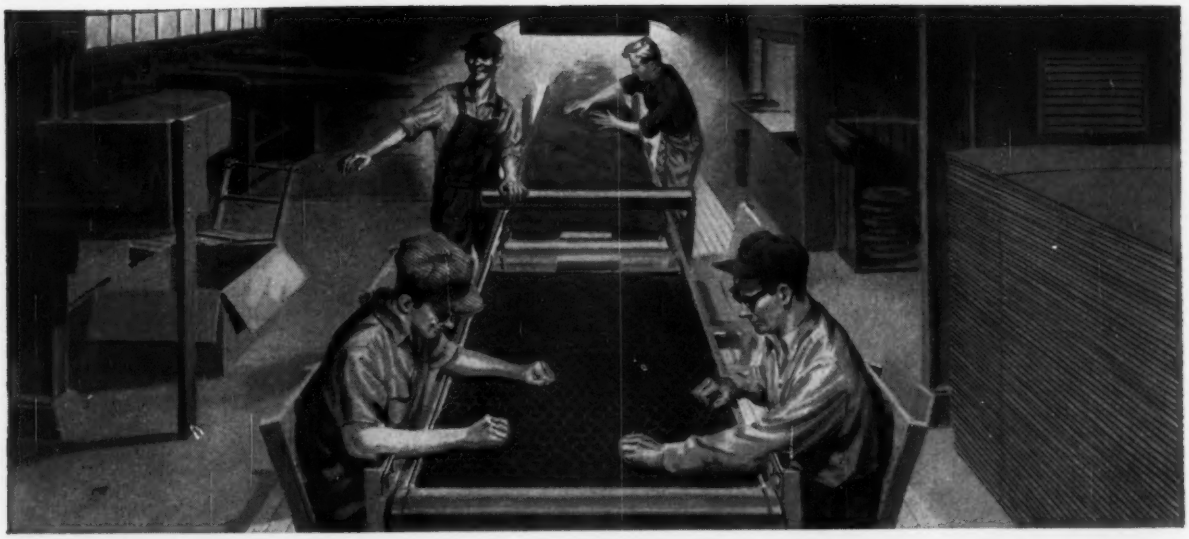

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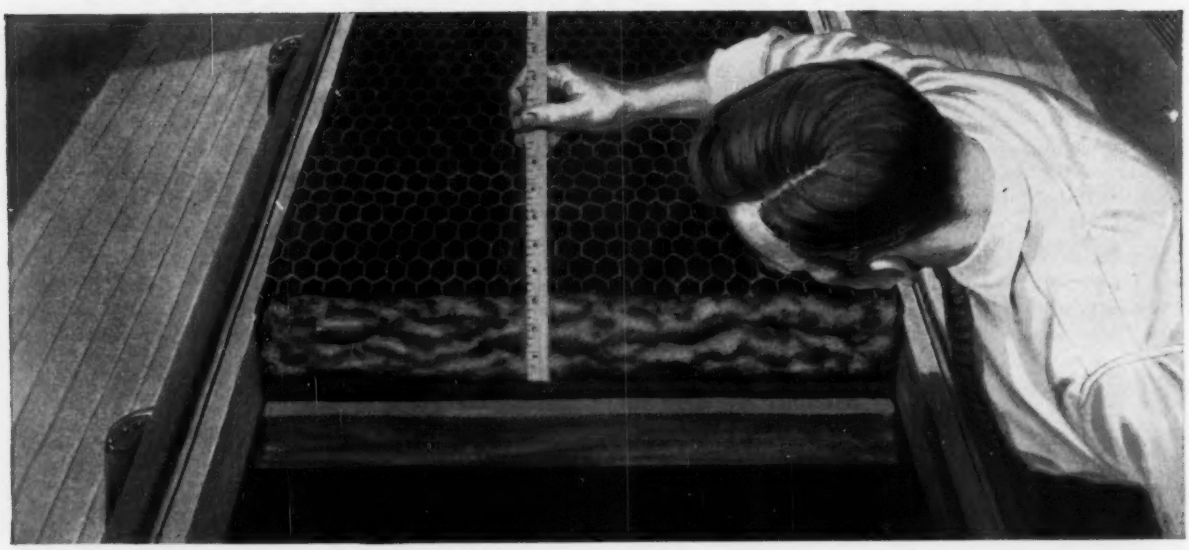

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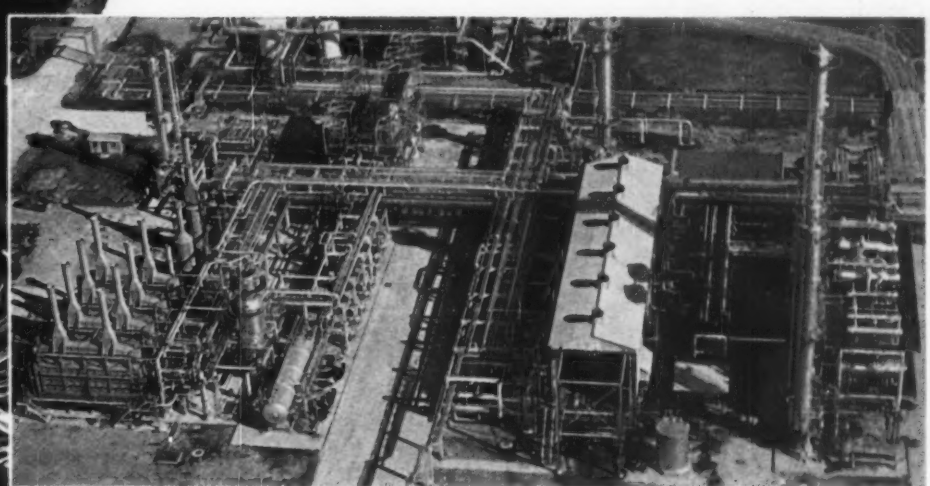

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The authors, estimators by profession, have found after much comparison on many projects, that production efficiency percentages can be classified into five categories: very low, low, average, very good and excellent. Production elements can be grouped into six different listings: general economy, project supervision, labor relations, job conditions, equipment, weather.

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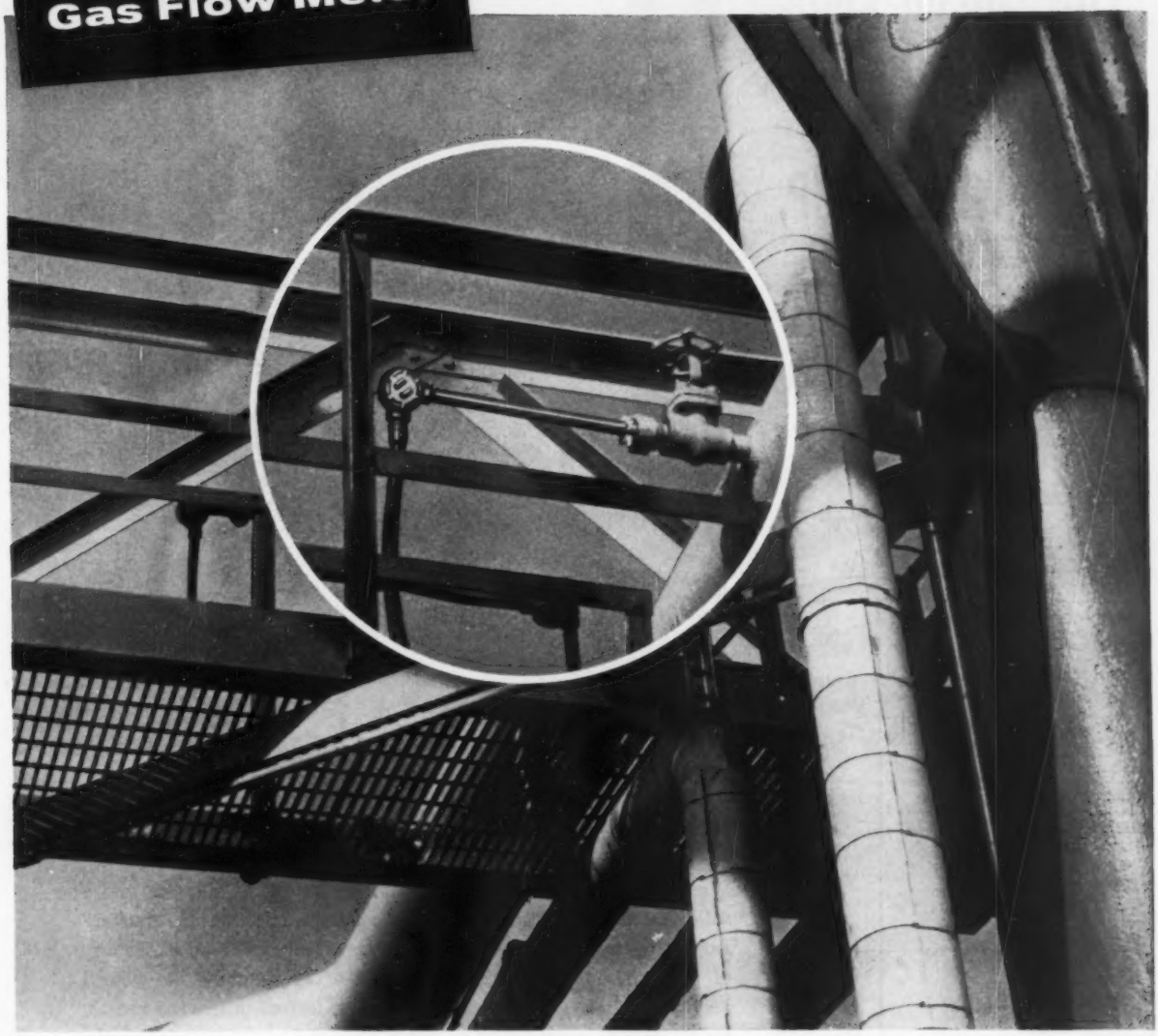

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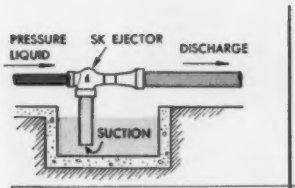
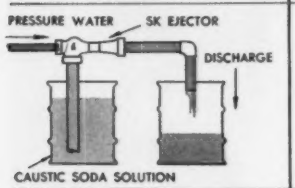
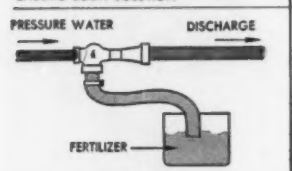


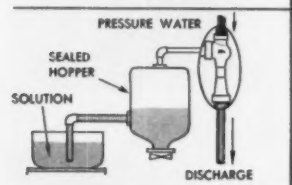
Pumping out a sump



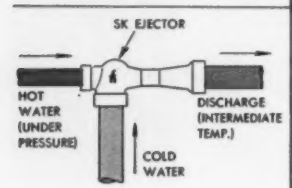
Diluting caustic



Handling slurry



Evacuating air (vacuum lift)



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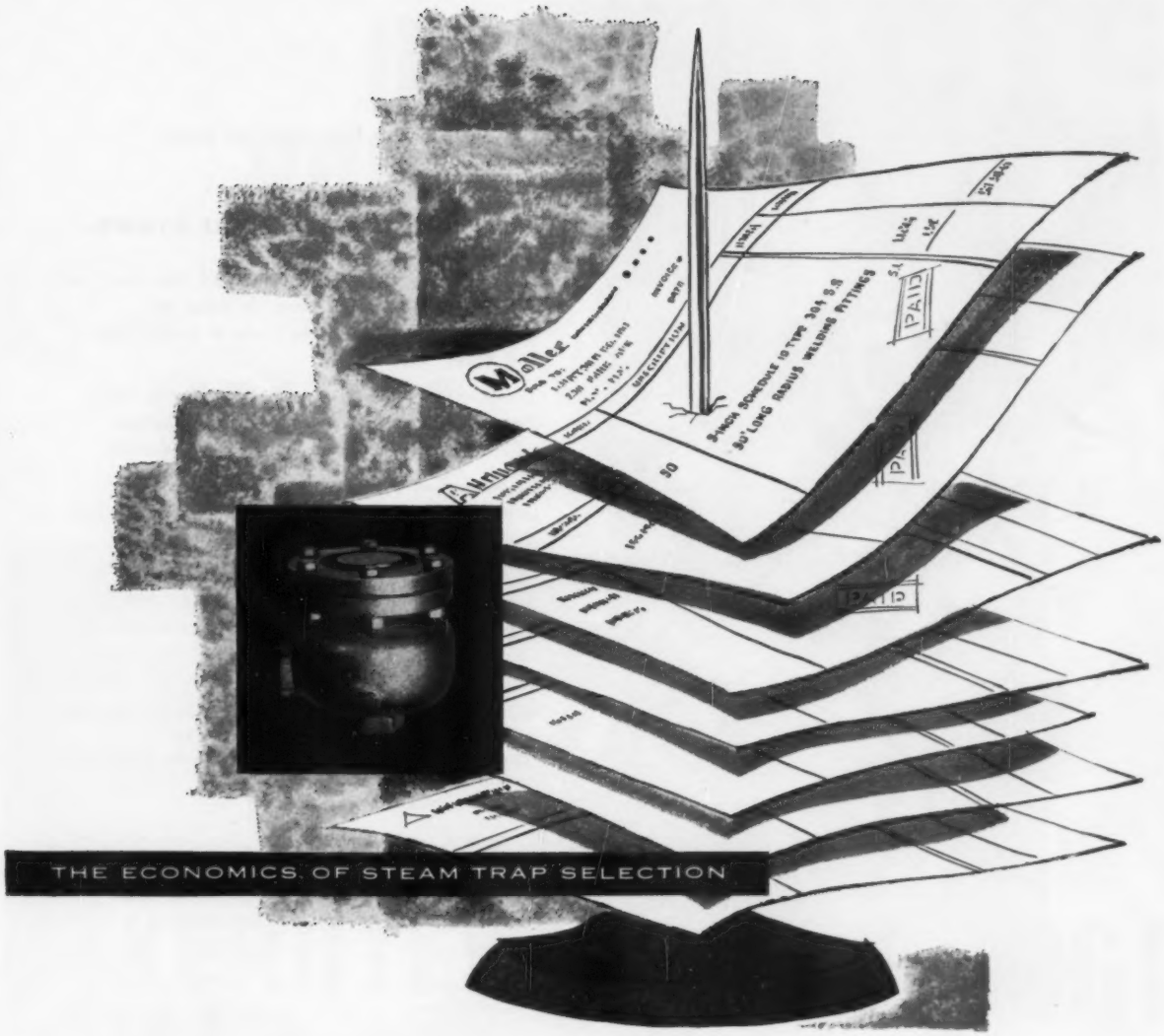

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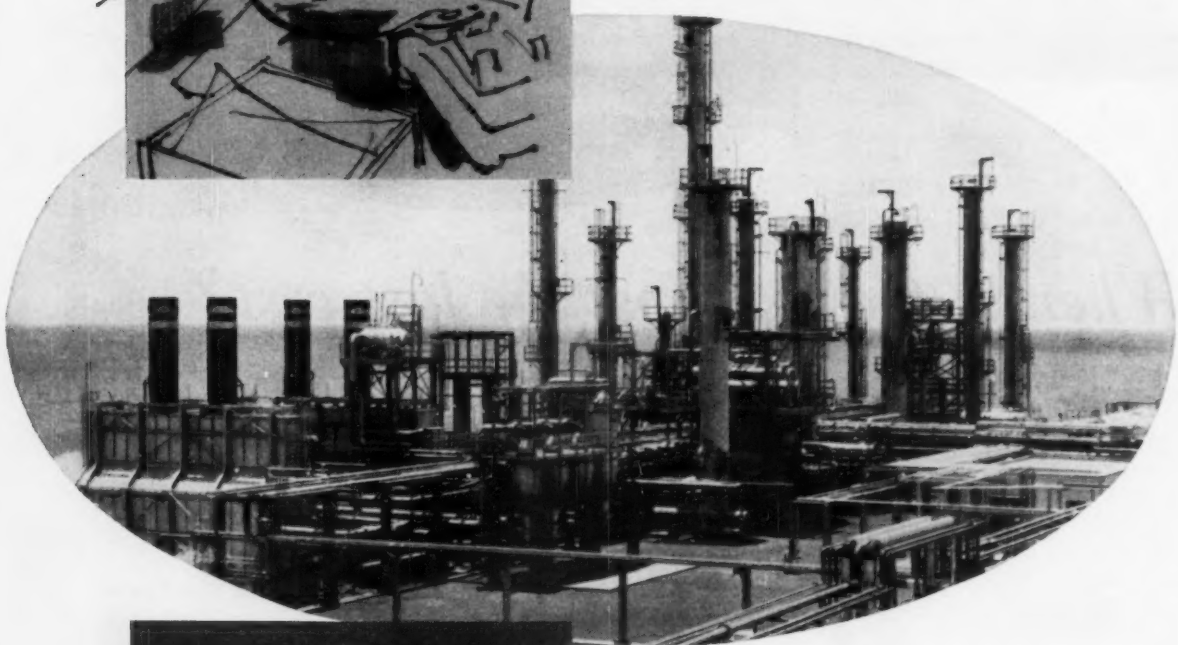

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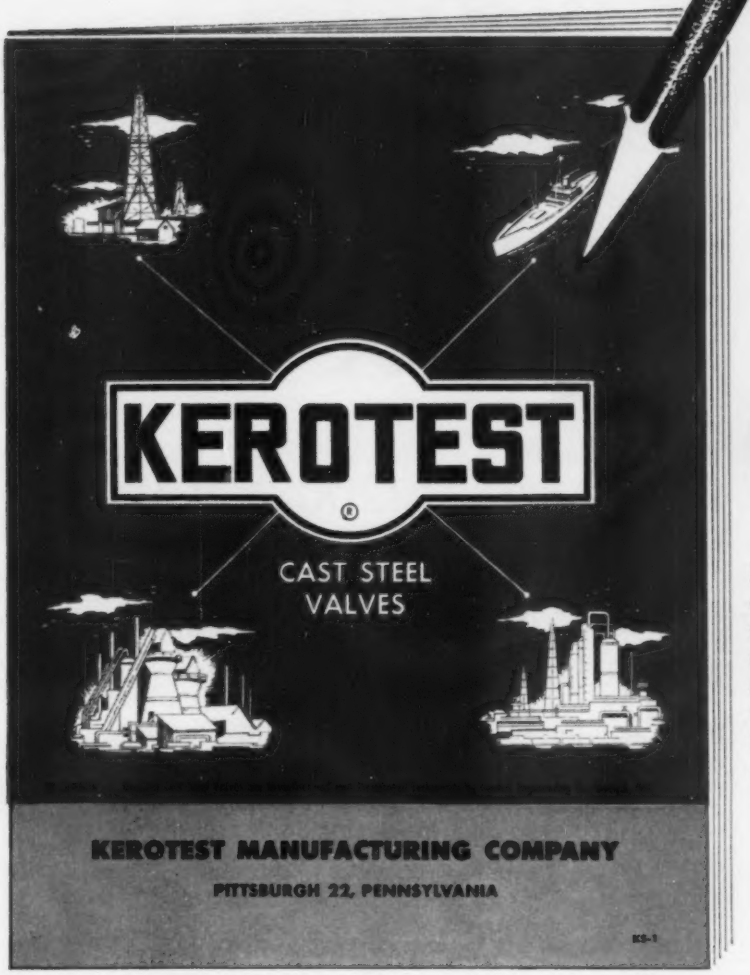

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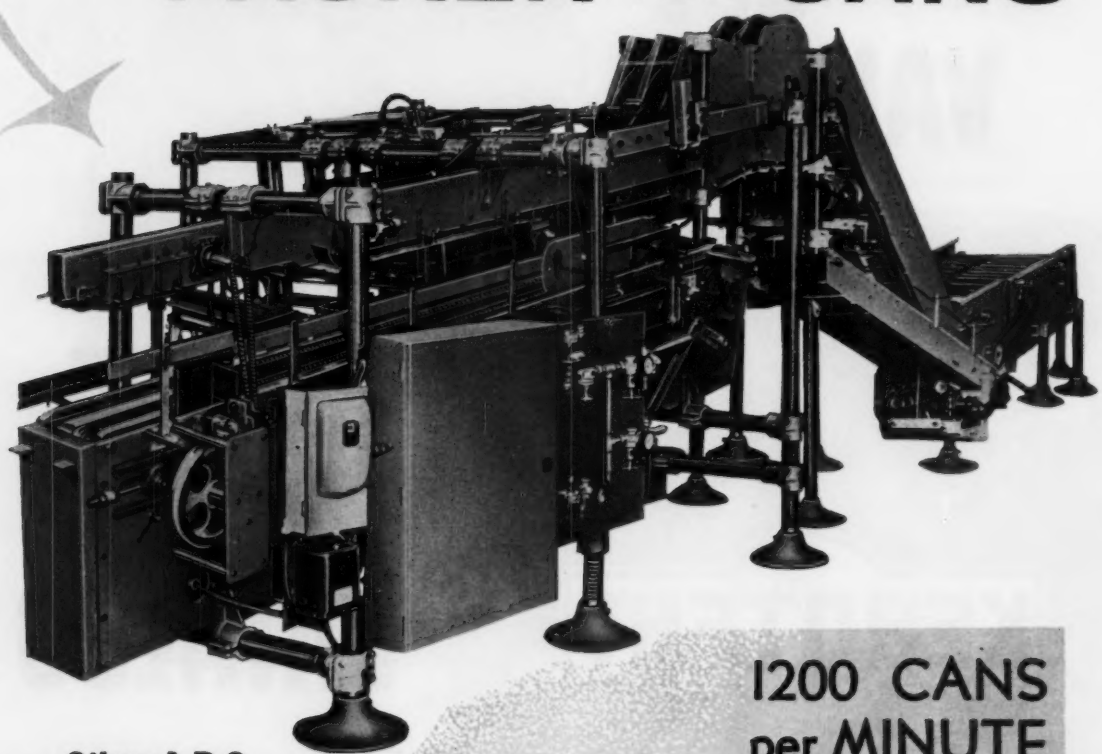

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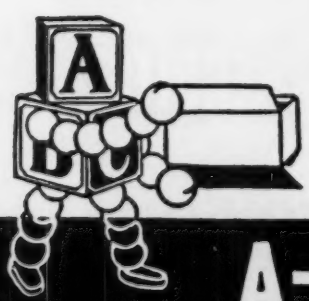

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The continuous readings from a Bailey HEAT PROVER Analyzer enable operators to correct combustion variables before costly losses are incurred. The two meters on the analyzer show per cent by volume of oxygen and combustibles on either a 20% range span or a more sensitive 4% range. Temperature of the gases in degrees Fahrenheit may also be shown.

To order or get additional facts, write us direct or contact any of our District Offices. You'll find them listed in Chemical Engineering Catalog, Refinery Catalog, Thomas Register, or Mechanical Catalog.

Gas analysis with Bailey HEAT PROVER Analyzer at a process heater. Per cent oxygen and combustibles is shown continuously while testing.

CP106-1

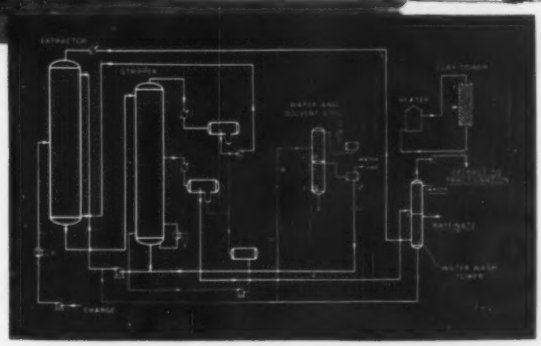
Chemical and petroleum division

BAILEY METER COMPANY

1043 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

UDEX®



The ideal process for separation of super-purity aromatics

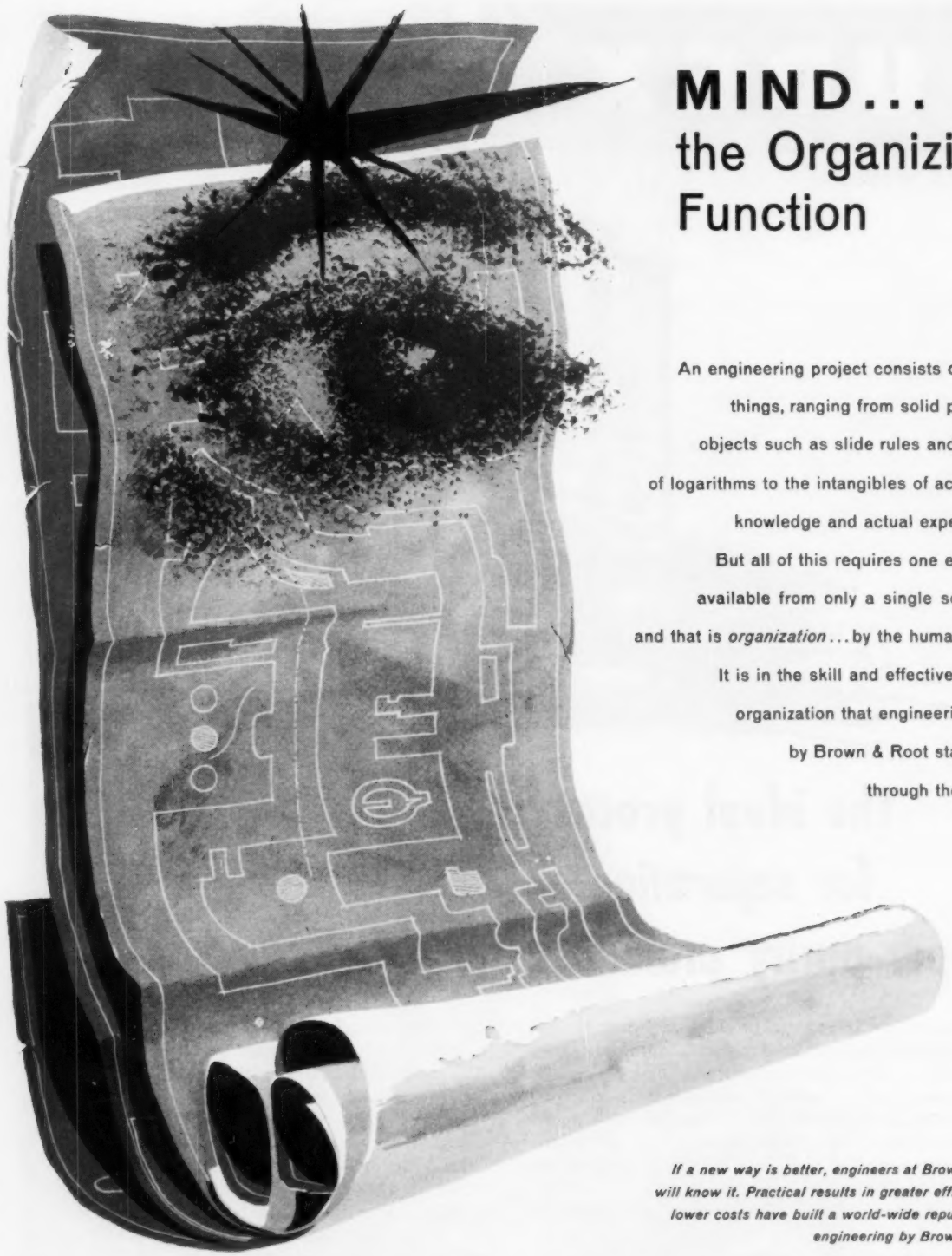
You can get substantial production of high-purity aromatics and still keep costs at a minimum with UOP's Udex extraction process. Udex-processed benzene, toluene and xylenes not only meet nitration-grade specifications but exceed these requirements in purity. These aromatics are produced at extremely low cost, since relatively inexpensive and readily available glycol solvents are used in the process. Utility requirements are considerably lower, too. The versatile Udex process permits recovery of aromatics from catalytic reformates, from by-product light oils produced in coke-oven operation, from thermal aromatic concentrates such as ethylene co-product light oil fractions and other aromatic-rich by-products. Although most petrochemical processors place major emphasis on recovery of benzene, toluene and xylenes, the Udex process also permits recovery of heavier aromatics and dicyclics in high purity. Udex is just one of many UOP refining and petrochemical processes available to the entire refining industry. A complete booklet on the UOP Udex process has just been published and is yours for the asking. For a detailed description of this process, how it works and the economic factors of cost and production, write us on your company letterhead.

UOP®

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U.S.A.

More Than Forty Years Of Leadership In Petroleum Refining Technology



MIND... the Organizing Function

An engineering project consists of many things, ranging from solid physical objects such as slide rules and tables of logarithms to the intangibles of academic knowledge and actual experience. But all of this requires one element, available from only a single source — and that is *organization*... by the human mind. It is in the skill and effectiveness of organization that engineering jobs by Brown & Root stand out, through the years.

If a new way is better, engineers at Brown & Root will know it. Practical results in greater efficiency at lower costs have built a world-wide reputation for engineering by Brown & Root.

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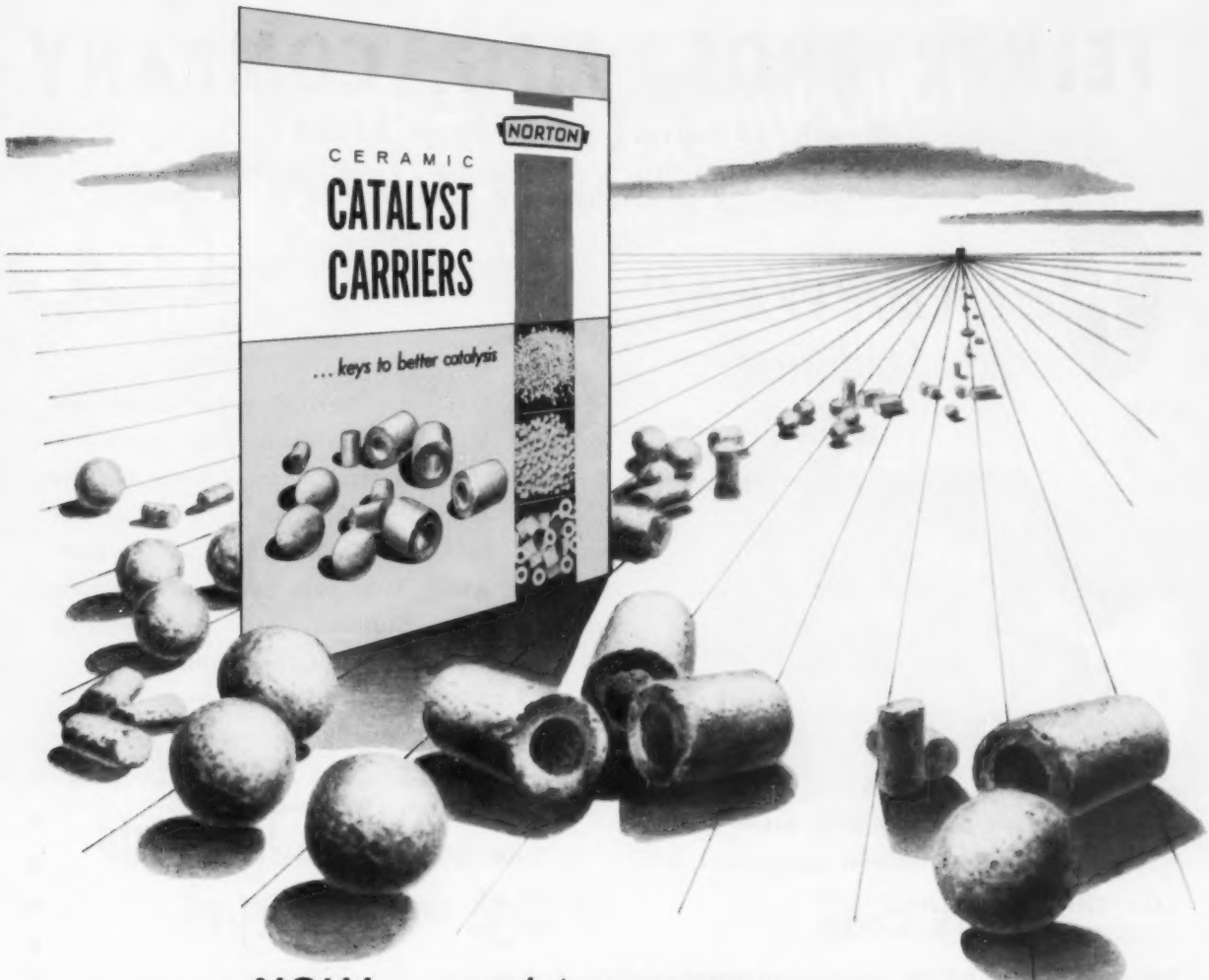

NOW . . . and tomorrow . . .

choose NORTON Ceramic Catalyst Carriers

In columns and reactors throughout the chemical and petrochemical industries, NORTON Ceramic Catalyst Carriers are helping processors to improve catalyst activity and life, lower catalyst costs, get optimum yields from reactions.

It's *consistent* high performance too, because *every* NORTON Carrier is uniform in *any* quantity from lot to lot. Size, weight, porosity, and purity are held to close tolerances. Duplication of specifications is assured.

Today, probably the most widely-used NORTON Carrier is alumina . . . in ring, sphere, and pellet form and as granules and powder. However, as new feedstocks are developed, and more demanding physical, chemical, and thermal conditions are encountered, new NORTON Carriers will be ready to meet catalysis specifications. For example, various materials are now available in experimental quantities as spheres, rings and pellets . . . in alumina, magnesia-alumina spinel, fused magnesium oxide, silica, zircon, zirconia and silicon carbide. These NORTON developments offer porosities ranging from 4% to 65%; surface areas from less than 1 to $70 m^2$/gram (BET method).

Also readily available is the technical assistance of the Norton Man. Through him, chemical engineers can draw upon the wealth of research and engineering data compiled over the years by the NORTON COMPANY. He is well qualified to help *you* meet catalyst carrier specifications exactly . . . efficiently . . . economically.

NORTON Carriers are described in detail in the Bulletin, "Keys to Better Catalysis". For your copy, or for technical assistance, write NORTON COMPANY, Refractories Division, 462 New Bond Street, Worcester 6, Massachusetts.

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REFRACTORIES
Engineered . . . Ry . . . Prescribed

75 years of . . . **Making better products . . . to make your products better**

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

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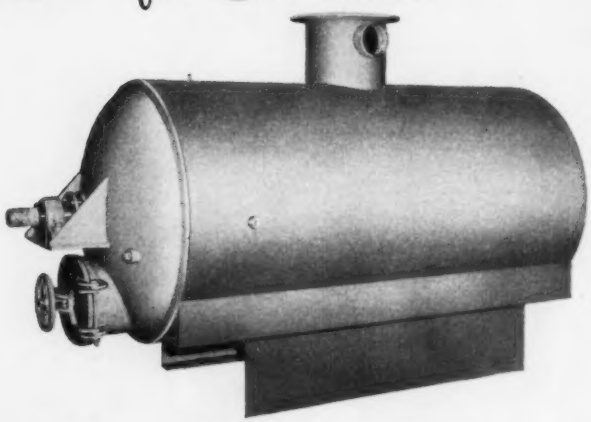
FELKER BROS. MFG. COMPANY

Metal Fabricators for OVER 50 YEARS

MARSHFIELD, WISCONSIN
Phone FUlton 4-3121

FELKERWELD for Endurance



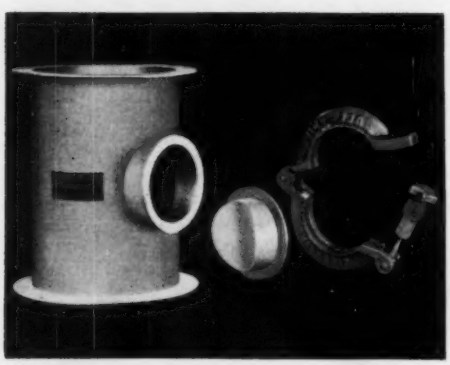
• A Pressure Cooker of open hearth mild steel fabricated to customer specifications.

ASME Code

Our shop is qualified for construction under the A S M E Code for unfired pressure vessels, paragraph U-69 and U-70.

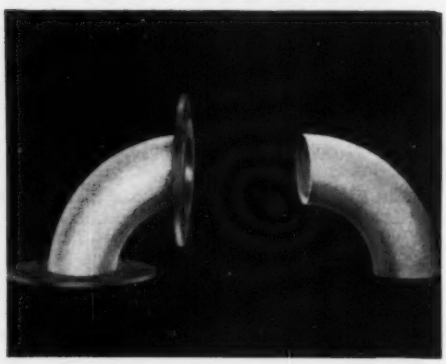
Our more than 50 years' experience in fabricating plain steel, applied to stainless steel when it came into the market enabled us to develop our FELKERWELD PROCESS for ENDURANCE, with such metals as Stainless Steel, Stainless Clad Steel, Inconel, Monel, Nickel, Copper and Aluminum Bronze. FELKERWELD is your guarantee for quality workmanship.

We Fabricate to Your SPECIFICATIONS



• FELKERWELD plug type CLEAN OUTS with quick opening Vee Grip Flange.

We invite inquiries on any Fabricated Products . . . write, phone or wire . . . estimates promptly furnished. Ask for our Bulletin No. 505.



• FREEFLOW Type Stainless Steel Elbows —Fittings available in all metals.

FELKER BROTHERS MANUFACTURING CO.

Phone FUlton 4-3121 - MARSHFIELD, WIS.

FALK Steelflex SPACER COUPLINGS
save time and money in refinery operations

FALK and STEELFLEX are Registered Trademarks

Cut disconnect-reconnect time by as much as 50%

The FALK Spacer Coupling is specially designed for quick installation or removal *without disturbing the driving or driven unit*. This feature can save you up to 50% in disconnect-reconnect time when critical equipment—a process pump, for example—needs repair or replacement.

Here's another saving: with the FALK Spacer Coupling, you can quickly realign shafts *without the usual loss of operating temperature!*

And still another: you can remove or reinstall the FALK Spacer as a unit *without draining the lubricant.*

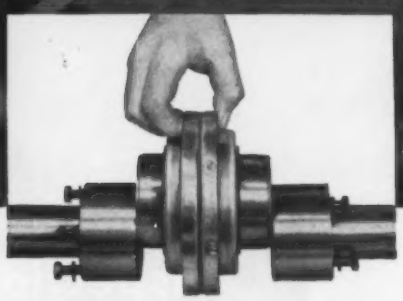
Because of its exclusive grid-groove Steelflex design, the FALK Spacer can accommodate residual misalignment—parallel, angular, or (most important) *both*. Also, it provides torsional resiliency that cushions shock and vibration. Thus it saves wear-and-tear on your connected equipment.

To prove these claims and enjoy these savings, install a FALK Spacer on one application—and see for yourself. Consult your FALK Representative or Authorized Distributor.

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN

MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

Representatives and Distributors in many principal cities.

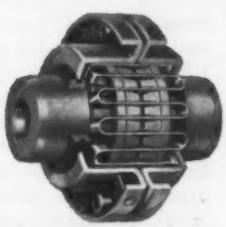


EASY AND QUICK TO INSTALL, DISCONNECT OR RECONNECT

First, mount shaft hubs to allow proper distance between hubs; then, align driving and driven units.

Second, compress Spacer to fit space between hubs and tighten cap screws to pull spacer hubs into the registered fit.

To disconnect, reverse the second step. No draining of lubricant necessary.



The heart of the FALK Spacer ...the basic Type F Steelflex

Write for Service Manual 4838

FALK

...a good name in industry

Here's Why Oil Men Specify
EC&M HIGH VOLTAGE STARTERS

2200-4800 Volts
Totally Oil-Immersed

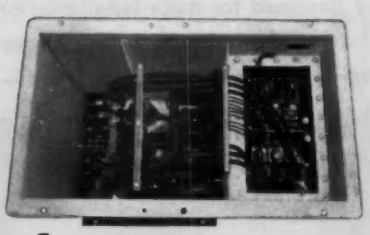
EC&M Type ZHS Starters at Southwestern pipe line trunk station

Designed for Easier Installation, Inspection and Maintenance

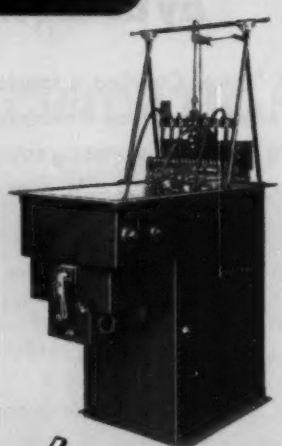
Specifically designed for Class I, Group D, Division 2, semi-hazardous locations . . . NEMA 3R (raintight enclosure). 50,000 KVA interrupting capacity.

***Fast* installation** because starters are shipped with all internal wiring complete. All leads are of anti-syphon construction.

Easy inspection • Contactor and overload relay panel may be raised, as one unit, above oil level. No disconnecting of bolts or leads. *(See lifting mechanism at extreme right.)* Safer, too . . . note view windows on each side of load-break disconnect switch.



View from above shows complete internal wiring . . . anti-syphon leads. These "ready-to-use" starters are complete with control transformer for 220 volt push button operation.



EC&M Contactor lifter raises contactor and overload relay above oil level for easy inspection. No bolts or leads to disconnect.

For literature describing EC&M's complete starter line, write for Bulletin 8131-T

SQUARE D COMPANY
EC&M DIVISION • CLEVELAND 28, OHIO

wherever electricity is distributed and controlled

8020

This is THERMAL FATIGUE

This photograph shows a heat-resistant furnace tube after thermal fatigue failure.

Thermal fatigue failure begins with cyclical temperatures and variable heat inputs. These conditions produce nonuniform thermal expansions and contractions. As a result, strong, hindered expansion and contraction stresses develop. These stresses produce plastic flow which results in the tube deformation shown above. Deformation of this type curtails furnace operations and constitutes thermal fatigue failure. Progressive deformation or severe thermal fatigue stresses will cause tube-rupture failures.

Thermal fatigue is an inherent problem in heat-resistant components, cast or wrought. As such, it occupies an important place in Electro-Alloys research efforts to lengthen life of components working under high temperatures and severe cyclical conditions.

We have created apparatus that assesses and analyzes the variables of thermal fatigue. Check with your Electro-Alloys representative for the meaning of our thermal fatigue data as it pertains to the material specification, design and service conditions of your heat-resistant components.

Send for free technical booklet on Thermal Fatigue

Please send me free copy of "The Mechanism of Thermal Fatigue," by Howard S. Avery—comprehensive report based on extensive lab studies:

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Electro-Alloys, 2023 Taylor St., Elyria, Ohio

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION • Elyria, Ohio

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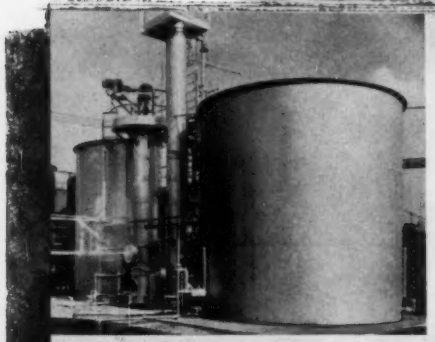

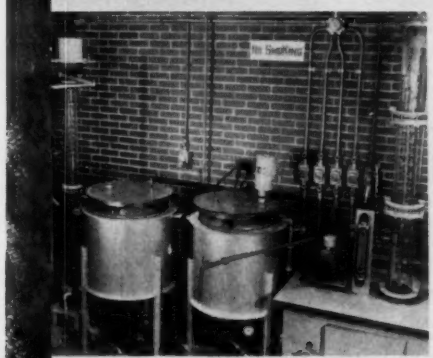

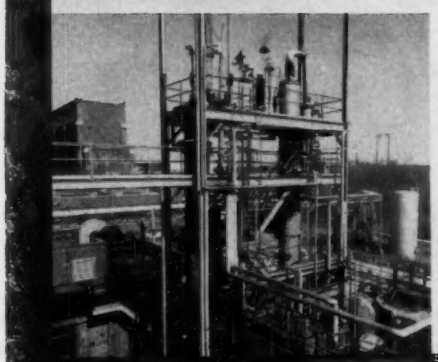

as a new and useful chemical engineering tool, the Turbo-Mixer Rotating Disc Contactor has proved its efficiency in many commercial applications

TYPICAL SYSTEMS IN SERVICE . . .

Furfural—lube oil extractions.

Extraction of essential oils.

Extraction of water soluble chlorinated organics.

Extraction of unsulfated organic materials from ester salts.

Extraction of mercaptans from gasoline fractions by caustic soda, "Dualayer" or "Solutizer" solutions.

Extractive purification of pharmaceuticals.

Extraction-separation of tar components.

Extractive recovery of valuable organics from waste waters.

Propane deasphalting of lube oil and of cat cracker feed.

Phenol extraction from waste water.

Caffeine extraction.

Vanillin extraction.

Caustic extraction of acids from organics.

Removal of trace contaminating hydrocarbons from plating solutions.

Separation of Hafnium from Zirconium.

CAN YOUR PLANT PROFITABLY USE AN RDC COLUMN?

You may find the answer in this booklet!

Above you see RDC columns in successful operation for manufacturers of chemicals, petro-chemicals, petroleum and foods. Production size or pilot plant models available. Write or phone General American for Bulletin #T-1159. If you wish, our engineers will be glad to discuss your requirements and recommend the equipment that will do your work most efficiently.

Process Equipment Division **TURBO-MIXERS**

GENERAL AMERICAN TRANSPORTATION CORPORATION

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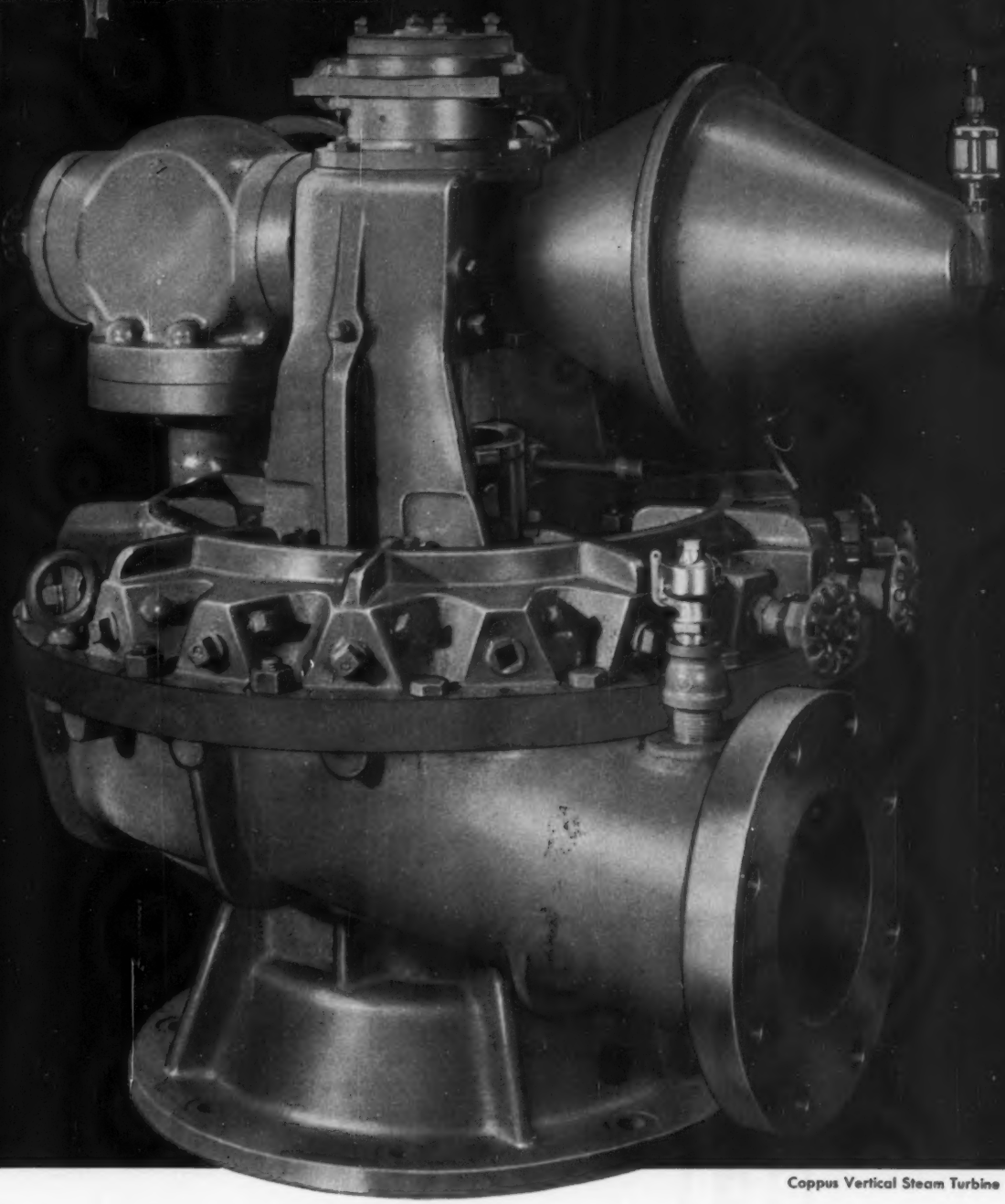
Offices in principal cities

COPPUS BLUE RIBBON PRODUCTS



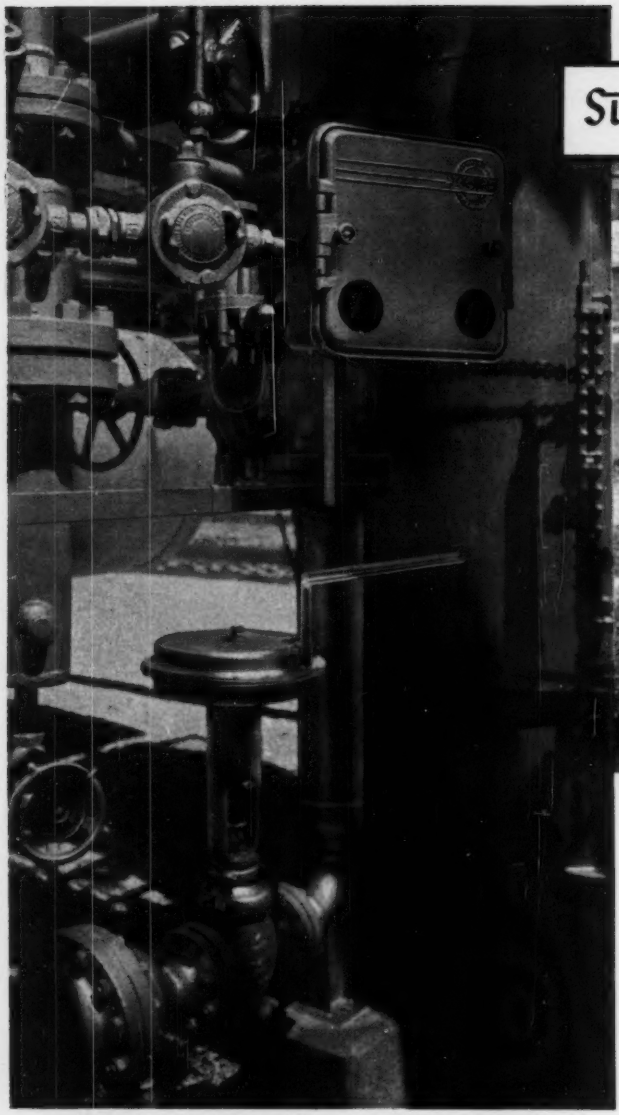
Coppus Vertical Steam Turbine

THE MARK OF QUALITY — There's no better test of a turbine's quality than performance. And the new, ruggedly designed, power-packed Coppus Turbines pass all performance tests with top honors! Small wonder. Coppus quality is literally designed and built into them. Their super stamina is the end-product of painstaking craftsmanship, finest materials and methods, thorough testing and control. Each truly deserves its Blue Ribbon . . . assurance of *complete* reliability.

Typical Coppus Blue Ribbon features are: *totally enclosed governor . . . totally enclosed and independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.* You get higher efficiency operation . . . less down time . . . lower maintenance costs.

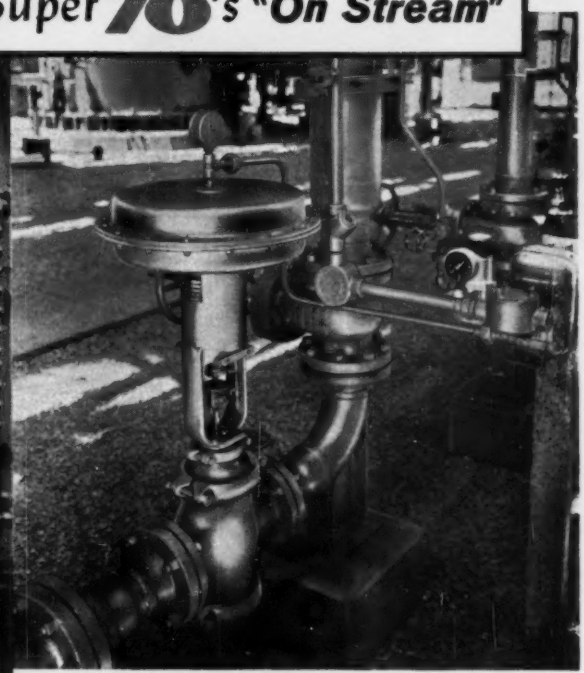
Coppus Turbines are built to customers' specifications, including API and NEMA standards. Send for Catalog 200. Get complete details on Coppus Turbines. Sizes from 1 HP to 250 HP. Write COPPUS ENGINEERING CORPORATION, 413 Park Avenue, Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES



BS&B Liquid Level Control for Propane Refrigeration System

Super 70's "On Stream"



Super 70 Diaphragm Control Valve
as Debutanizer Reflux Flow Controller

BS&B

ELECTRO-PNEUMATIC CONTROLS SERVING WARREN'S MONT BELVIEU PLANT

In their Mont Belvieu Fractionation Plant, Warren Petroleum Corporation separates propane, isobutane, normal butane and natural gasoline. Efficient day in, day out operation of this large plant is assisted by BS&B Super 70 Control Valves, Liquid Level Controls and Regulators.

A complete modern electronic control system was designed and installed in Mt. Belvieu for the control of precise product purity. BS&B's level controls and control valves were selected as primary and final control elements, due to their superior performance characteristics and rugged dependability.

BS&B Controls are proving their superiority in service the world over. Specify them on your next job.

OVER 40 YEARS
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Controls Division, Dept. 4-F3
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Calcium Silicate Insulation

Thermasil now offers more advantages than ever before. Take the matter of strength! The hardness of a calcium silicate should be sufficient to permit safe and easy handling, resist damage from vibration and accidental concussion—yet not be too hard, because low application costs depend on being able to use conventional tools. Only Thermasil has this ideal combination of strength and toughness. And there are other advantages in durability, "hinge strength," freedom from shrinking, warping and cracking.

Continuing product improvement by Baldwin-Ehret-Hill makes it essential to keep your ideas fresh - with timely, accurate knowledge of constantly changing insulation materials. You'll realize that old specifications are of little value in writing new ones for modern installations. Baldwin-Ehret-Hill offers you the complete line—a selection of over thirty specialized insulations for service from sub-zero to 1900 F. To bring your specifications up to date, write for our 1960 catalog or see it in your Sweet's Files.

NOW IS THE TIME TO UPDATE YOUR SPECIFICATIONS WITH . . .

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THE COMPLETE LINE OF INSULATIONS for use SUB-ZERO TO 1900 F.

CONTRACT APPLICATION SERVICE FROM COAST TO COAST

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• Easy to Install and Maintain
HAGAN CHEMICALS & CONTROLS, INC.
PITTSBURGH, PA.

Send for this bulletin. Hagan's PowrMag analog computer control offers the highest degree of flexibility yet devised for industrial control. A new bulletin, MSP-163, shown above, gives full details on the system, the magnetic control units, the patchboard, and provides useful information on determining computer requirements.

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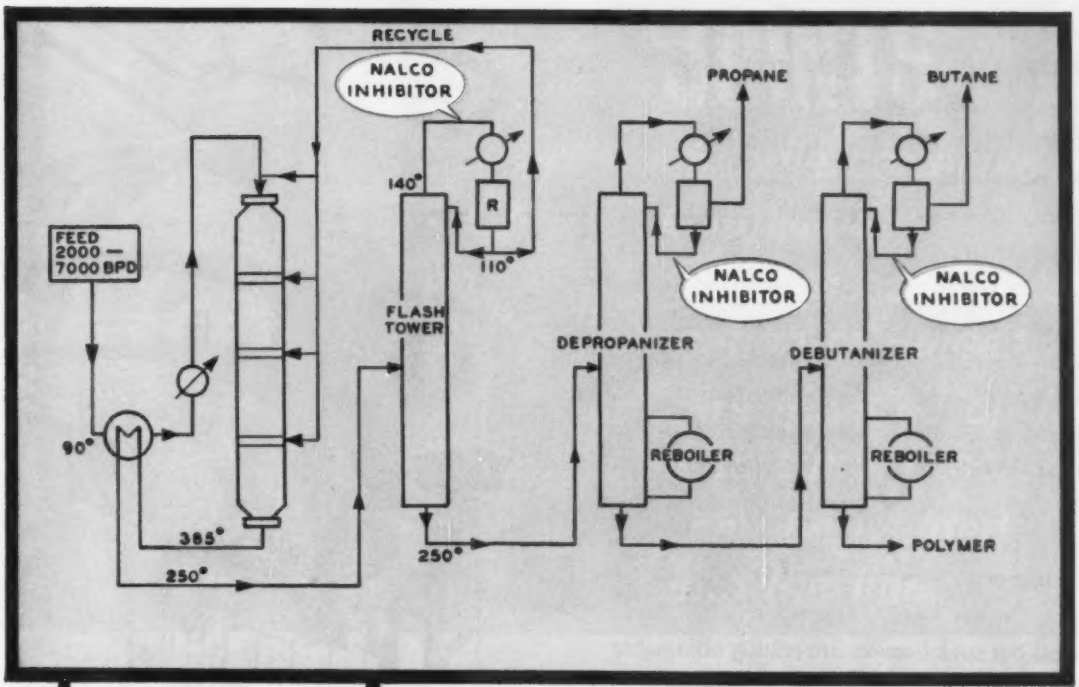
Nalco INHIBITORS

STOPPED CORROSION and FOULING

in this CATALYTIC POLYMERIZATION UNIT



THE PROBLEM

1. Corrosion of the steel tube bundles of the flash tower overhead condenser with accumulator water pH of 4.5 or below.
2. Serious fouling of screen trays in the depropanizer and debutanizer on normal six-month run.

THE TREATMENT

Nalco Inhibitor fed to the overhead of the flash tower, and to the reflux of the depropanizer and debutanizer towers.

THE RESULTS

1. Iron content of accumulator water reduced from .75 pounds per day to .04 pounds per day.
2. No deposits in screen trays after six-month run.

CONSIDER further the economy of dosage . . . 10 ppm to flash tower, and 10 ppm to depropanizer and debutanizer. And bear in mind that this was no isolated success story. The same advantages—less downtime, better thruput *and* effective protection for costly equipment—can be brought to your refinery by the use of Nalco Corrosion and Fouling Inhibitors. Ask your Nalco Representative or write direct.

National Aluminate Corporation is now

NALCO CHEMICAL COMPANY

6259 West 66th Place • Chicago 38, Illinois

Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany

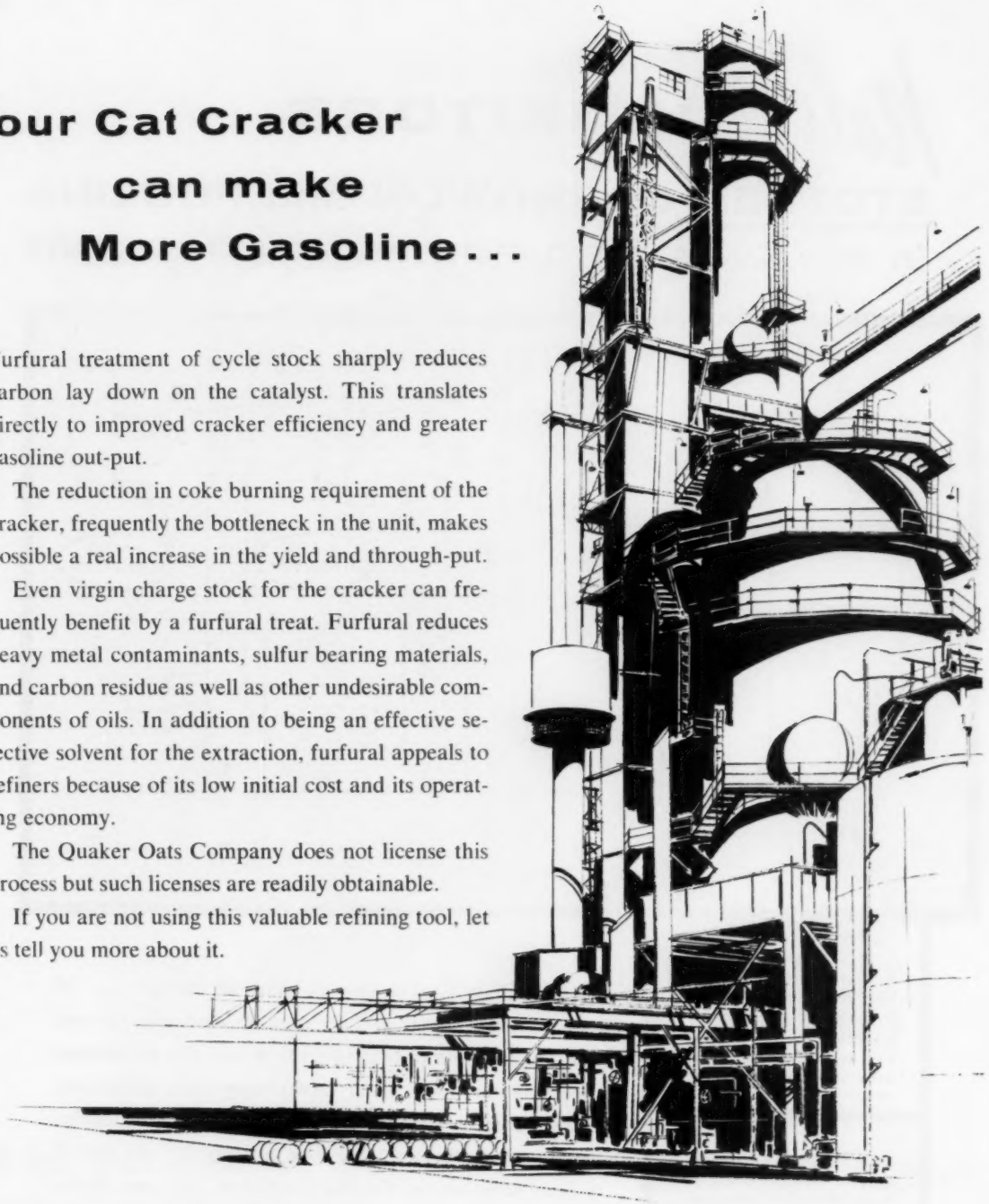
In Canada—Alchem Limited, Burlington, Ontario

THE *Nalco*® SYSTEM... *Serving Industry through Practical Applied Science*

Nalco CHEMICALS

For more data on advertised products, use Readers' Service Cards, last page.

Your Cat Cracker can make More Gasoline...



Furfural treatment of cycle stock sharply reduces carbon lay down on the catalyst. This translates directly to improved cracker efficiency and greater gasoline out-put.

The reduction in coke burning requirement of the cracker, frequently the bottleneck in the unit, makes possible a real increase in the yield and through-put.

Even virgin charge stock for the cracker can frequently benefit by a furfural treat. Furfural reduces heavy metal contaminants, sulfur bearing materials, and carbon residue as well as other undesirable components of oils. In addition to being an effective selective solvent for the extraction, furfural appeals to refiners because of its low initial cost and its operating economy.

The Quaker Oats Company does not license this process but such licenses are readily obtainable.

If you are not using this valuable refining tool, let us tell you more about it.

The Quaker Oats Company

CHEMICALS DIVISION

The Quaker Oats Company — Chemicals Division — QO Furan Chemicals

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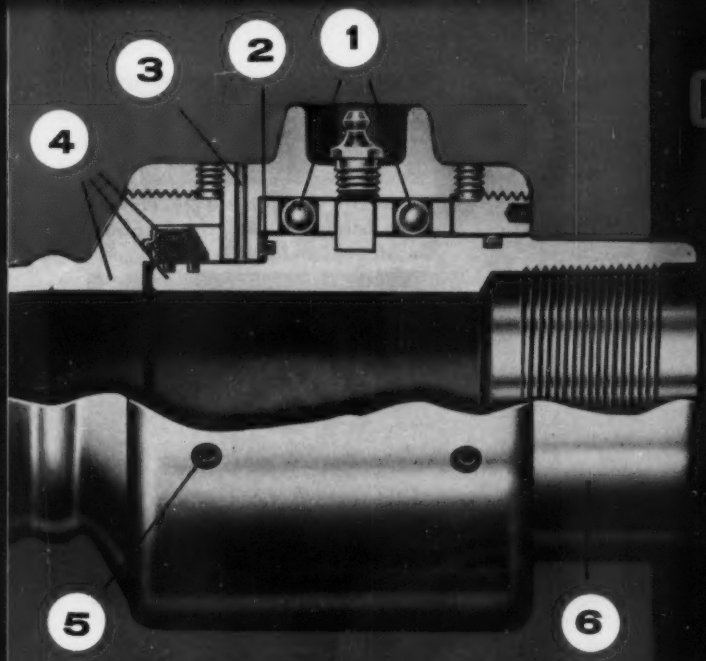

1. Wide Bearing Spacing . . No Split Races
2. Secondary Seal
3. "Weep Hole"
4. Only Wettable Parts and Packing Contact Fluid
5. Simple Set Screws Allow Joint to Break Like a Union . . Bearings and Other Parts Not Disturbed
6. Thread, Weld, Flanged End Connections Available

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US TYPE SWIVEL JOINTS

..handle corrosive chemicals

..stop grease contamination of fluids

..are repaired on location with simple tools

..can be welded into the line

Continental-Emsco US Type swivel joints are designed *exclusively* for the Refining, Petrochemical, and Chemical industries. Fluid contacts metal and packing only, so wettable parts of corrosion resisting stainless steel (or other alloys) can handle all types of caustic products. Primary Teflon packing, *deformed* into grooves for a tight seal, and a secondary asbestos seal prevent grease from contaminating products. Packing chamber design is patented. It reduces bearing wear by preventing packing from pressing against bearings, and allows free swiveling regardless of internal pressure. Joints break like a union without unseating ball bearings and other parts. Joint can be welded into line, eliminating costly flanges. Threaded and flanged ends are also available. Wide bearing spacing through use of solid bearing races insures accurate alignment and provides maximum bearing support for internal and external loadings. Races are separate and can be reversed to double their life. Repairs and adjustments are made on the spot, without special tools . . shop or factory equipment not required.

Save installation and maintenance costs by designing, building or replacing with Continental-Emsco swivel joints. There's a size and type to meet all your product handling problems. Let us bid on your next requirement.

New Swivel Joint Catalog Now Available . . Write for It Today.

CONTINENTAL-EMSCO
Industrial Products Division
P. O. Box 359, DALLAS 21, TEXAS

A Division of The Youngstown Sheet and Tube Company

CONTINENTAL-EMSCO COMPANY • P. O. Box 359-3R • Dallas 21, Texas

Gentlemen: Please send me your current Swivel Joint Catalog. We are planning:
( ) New installation ( ) Replacement ( ) Catalog File

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COMPANY _____

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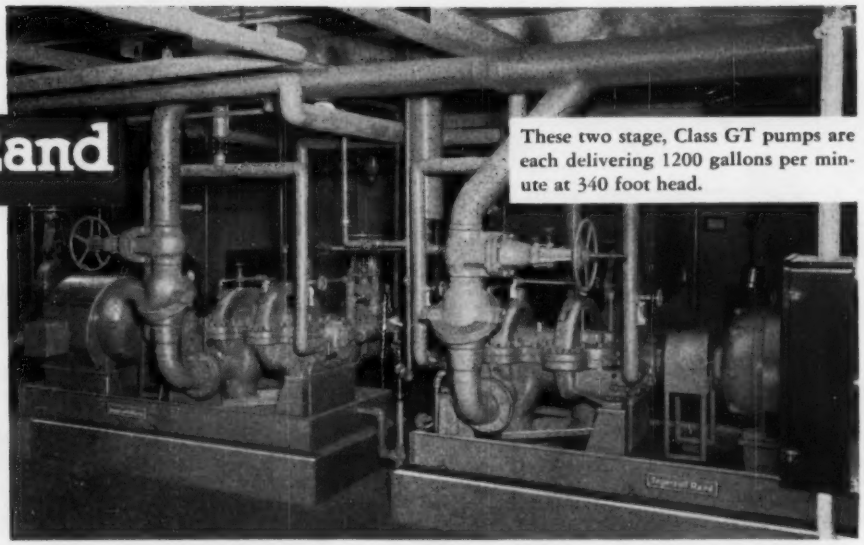
PLEASE PRINT

SJ902

Ingersoll-Rand



These two stage, Class GT pumps are each delivering 1200 gallons per minute at 340 foot head.

design flexibility can exactly match pump to service requirement

Ingersoll-Rand horizontally split, two stage centrifugal pumps are built for long life and designed for a wide variety of applications. These dependable, 24 hour-a-day duty pumps suit any installation requiring large volume deliveries at high heads.

They are available with single or double suction impellers and can be furnished in special materials to suit unusual conditions. They're ideal pumps for power plants, paper mills, mines, breweries, canneries, packing plants, refineries, iron and steel mills and general industrial service.

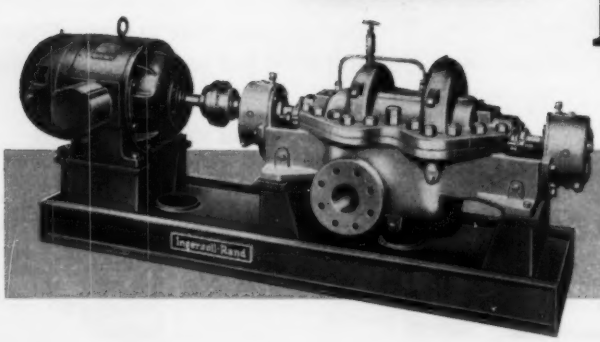
Get the full story from an experienced I-R pump engineer. He can tell you all about these pumps available in 2 to 6 inch discharge size for deliveries to 2000 gpm . . . heads to 1100 ft . . . horsepowers to 400.

a century 1860 – 1960 *of pump progress*

from the leading manufacturer . . .

Ingersoll-Rand

74A9 **11 Broadway, New York 4, N. Y.**



OTHER I-R PUMPS AVAILABLE

Motorpumps | Self Priming Pumps | Cradle Mounted Pumps

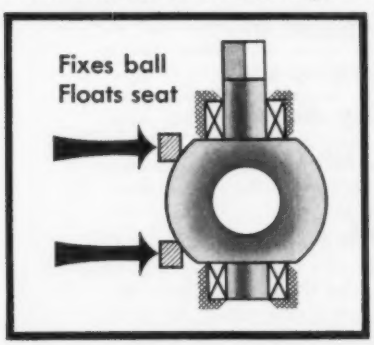
Can A Ball Valve Operate, Cycle After Cycle, With No Maintenance At All?

Read this remarkable answer, and discover an amazing engineering feat.

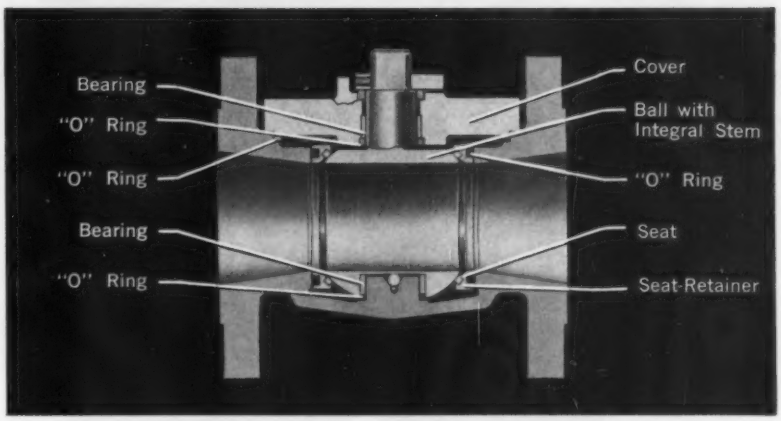
As most engineers know, ball valves offer a number of distinct advantages over all other types of valves . . . 90° on-off, minimum pressure drop, positive on-off indication, no lubrication, and compactness. In common with other valves, however, the design was insufficient to overcome the problem of continual maintenance.

Four years ago, this problem was faced by Hydromatics, Inc. in the valves that they produced for use in missiles, aircraft and ground support systems. Then, as today, all other ball valves were built with a ball that floated in its socket, and sealed by being forced against its seat by the pressure in the line. This caused seat distortion which made early replacement necessary.

Hydromatics tried a different approach. Rather than use the traditional floating ball, their engineers fixed the ball in bearings.



In the bearing-fixed **FLO•BALL** valve all pressure forces exerted on the ball are transmitted to low-friction bearings, thus eliminating down-stream seat distortion due to ball load. The pressure balanced seat, with its teflon sealing surface, is continually self-adjusted by the O-ring in the seat retainer.

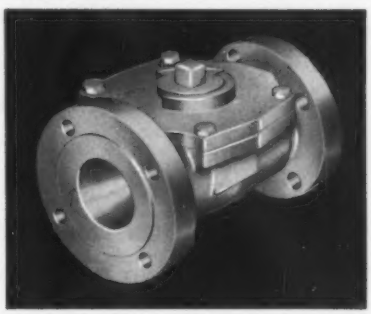


This O-ring acts as a self-energizing force that keeps the teflon seat always in contact with the ball. This insures positive sealing without seat distortion, and minimizes seat-resisting frictional forces. The combination of these low frictional forces results in low operating torque and extremely long seat life.

The bearing-fixed **FLO•BALL** valve proved itself immediately. Hundreds of missile and spacecraft systems, previously impossible, were made possible with these valves. The X-15, America's first manned space vehicle, for instance, has a Hydromatics **FLO•BALL** valve at its heart. Since its inception, the **FLO•BALL** has been used in more varied applications than all other ball valves combined.

Now, after the toughest application testing in history, bearing-fixed **FLO•BALL** valves are being mass produced for industry. They are available for off-the-shelf delivery to standard ASA dimensions in semi-steel, carbon steel, stainless steel, and aluminum. They operate at pressures to 600 psi, temperatures to 400°F and hold vacuum to 10^{-9} mm. of Hg!

The bearing-fixed **FLO•BALL** offers extra ball valve advantages. Top loading for easy access without removing the valve from the line, plus three features that are absolutely unique! Self-adjusting seats which automatically compensate for wear, proportional sealing force which automatically increases with line pressure, and the lowest torque, by far, of any valve. These combine to make the **FLO•BALL** valve virtually maintenance-free!



How long does it last without maintenance? Frankly, we don't know, since the first valves we ever built are still going strong and outlasting other valve types by more than 10-to-1. But don't take our word for it. See for yourself. Call, write or TWX for further information.

Hydromatics, Inc.
Livingston, New Jersey
Telephone: WYman 2-4900
TWX-LIVINGSTON NJ 120

For more data on advertised products, use Readers' Service Cards, last page.

Get the jump on your critical piping problems by taking this bit of advice. For the sake of lasting satisfaction, including safety and economy, delegate the prefabricating and erecting of high-temperature, high-pressure piping *directly* to experienced specialists. On your next job . . . ask us in.

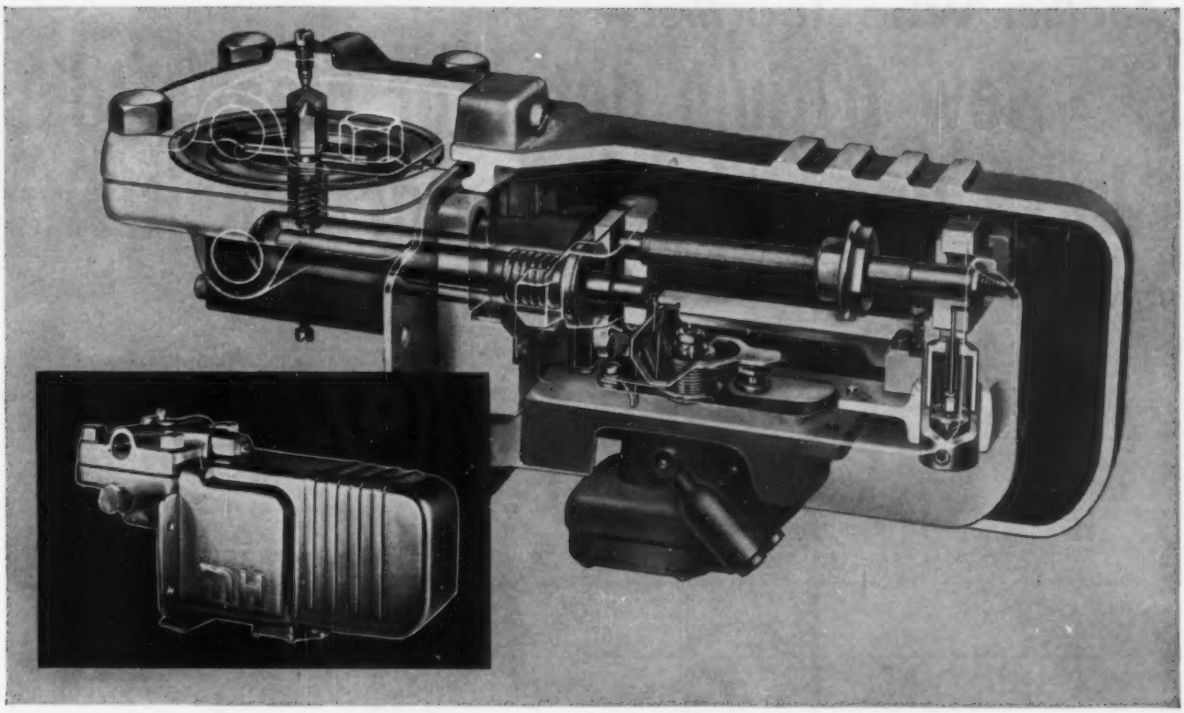
W. K. MITCHELL & CO., INC.

Philadelphia 46, Pa.

WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS



Three Honeywell Differential Converter* models give you...

Full-range control of flow and liquid level

1. For measuring gas and water flows: One model has a range of 0-5 to 0-25 inches of water. It can also be adapted to the measurement of specific gravity of liquids in open tanks. Available with *Buna-N* diaphragm.

2. For measuring liquid level in closed tanks: One model has a range of 14 to 50 inches of water, with maximum suppression of 75 inches. Another model, with a range of 50 to 200 inches of water, has maximum suppression of 200 inches. Available with *Teflon*** or *Viton A*** diaphragm.

3. For measuring flow and liquid level in open tanks: Two models with ranges from 0-20 to 0-200 inches of water differential and 0-100 to 0-1000 inches. Available with *Teflon* or *Viton A* diaphragm.

Now, standard models of the *Differential Converter* cover any range from 0-5 to 0-1000 inches of water—the widest choice of ranges we know of. And newly available *Viton A* and *Teflon* diaphragms make the *Differential Converter* ideal for a wide variety of applications. *Teflon* diaphragms are well suited for use with hard-to-handle fluids. *Viton A* has excellent mechanical properties which practically eliminate zero drift.

The *Differential Converter* measures gas and liquid flow or liquid level with accuracy within ±1% . . . and with rapid response, upscale and down. Range is continually adjustable in the field, without parts change, and field calibration is easily checked without weights. Air consumption is extremely low.

Compact and lightweight, these mercuryless transmitters can be mounted anywhere. They're ideal companions for Honeywell *Tel-O-Set** miniature instruments. Call your nearby Honeywell field engineer for full details. He's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

*Tradename, Minneapolis-Honeywell

**Tradename, E. I. du Pont de Nemours & Co., Inc.

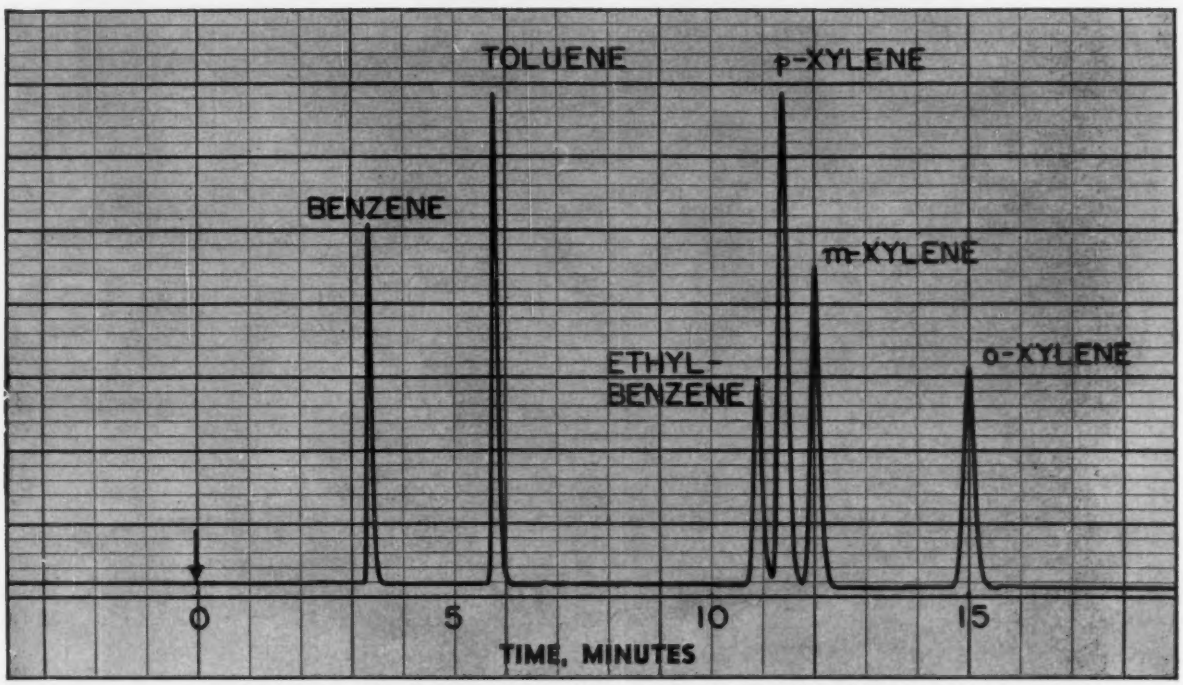
75th YEAR
PIONEERING THE FUTURE

Honeywell
First in Control
SINCE 1885

For more data on advertised products, use Readers' Service Cards, last page.

***Another* Wheelco *first*—**

New tritium detector means less base line noise, greater sensitivity



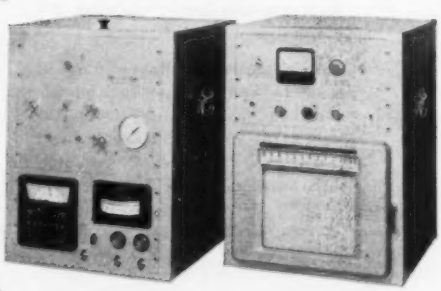
Chromatogram showing complete separation of xylenes using tritium detector and 60-ft stainless steel capillary column. Temperature, 67°C; flow rate, 0.7 ml/min Argon.

Now Wheelco offers a new tritium detector — to 225°C — in addition to the time-proved ionization detectors using strontium 90 and radium. Sensitivity is greater because tritium detectors have less base line noise than any other radioactive source: 1/3 as noisy as strontium and 1/30 as noisy as radium.

With a tritium source the detector offers the ultimate in simplicity and can be cleaned regularly. Long life with practically no maintenance or replacement is assured.

Outstanding operating flexibility is provided because the same detector can be used for capillary or packed columns.

See Wheelco first before selecting any chromatography equipment. New developments based on extensive field experience keep Wheelco ahead of the rest.



Model 20 is a compact, portable unit designed to use both capillary and packed columns. Wheelco also builds the Model 10, a laboratory unit for single or dual operation.

THE MARK OF QUALITY

BARBER COLMAN

Wheelco Instruments Division

BARBER-COLMAN COMPANY

Dept. C, 1597 Rock Street, Rockford, Illinois, U.S.A.

CHECKUP on your Control Valves... CHECKOFF these Annin Advantages*

*Any other source might give you a few... but with Annin you get them all!

MINIMUM number of parts per complete valve.

OVER 60,000 successful case histories of split body valve applications.

POSITIONING ACCURACY guaranteed, .001 inch per inch of stroke.

CONSTANT INSTRUMENT signal sensitivity throughout signal range.

COMPLETE INTERCHANGEABILITY of any Domotor valve to on-off pneumatic control, pneumatic hydraulic, electro hydraulic, electro pneumatic or manual actuator.

ENGINEERED FOR MANUAL control with any of the above automatic actuators, if desired, at minimum cost.

SIMPLIFIED ADDITION of high speed booster units to any pneumatic positioning actuator.

ADAPTABILITY of bellows seal, doolseal or plain extension to any standard valve.

BODY SIZES from ¼" up.

COMPLETE LINE of body ratings: 600—1500—2500 lbs. ASA; special 10,000 and 60,000 psig design, temp. —450°F to 1600°F.

CONVERSION FROM globe body to angle body construction with only one additional part.

ADAPTABILITY TO 3-WAY Valve Construction with minimum parts and cost.

MINIMUM COST for change from soft seat construction to hard seat, or vice versa.

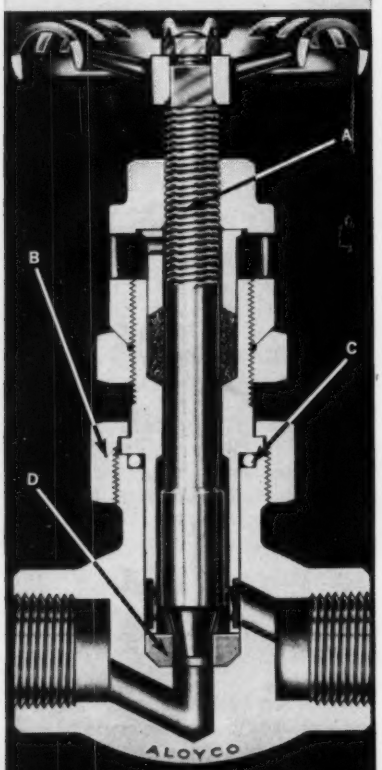
First in a series of checklists on Annin features.

Annin VALVES

THE ANNIN COMPANY
1040 South Vail Avenue
Montebello, California

For more data on advertised products, use Readers' Service Cards, last page.

Stainless Steel* Aloyco Needle Valve eliminates leakage and galling!



A. OUTSIDE STEM THREADS are away from corrosive area, prevent galling.
B. UNION BONNET provides extra strength and easy disassembly.
C. TEFLON O-RING provides tough, leak-proof seal.
D. TEFLON SEATS are pressure-tight, dependable, won't gall. Renewable.

Alloys available: 18-8S, 18-8SMo, Aloyco 20, Monel, Nickel and others.

This #62 Stainless Steel needle valve has proved itself for 10 years in many types of severe corrosive service. It is particularly suitable for sensitive control of flow as in metering, or sampling for process plant, laboratory or pilot plant use. For more facts write: Alloy Steel Products Company, 1303 West Elizabeth Ave., Linden, New Jersey.
0.4

Longer Lasting ALOYCO VALVES FOR IN CORROSIVE SERVICE

ALLOY STEEL PRODUCTS COMPANY

The Mail Box . . .

Fits Into Training

To the Editor:

Your article, "Get the Most from Instrumentation" in the December 1959 issue of PETROLEUM REFINER is very good and presents in a condensed manner what we do in our plant.

We would like to use this article as a training guide. Please advise whether reprints are available, etc.

F. C. Westfall, Jr.
Esso Standard Division
Humble Oil & Refining Co.
Bayonne, N. J.

Familiar Game

Wide response has come from readers of PETROLEUM REFINER's Look Box item, "A Game with Familiar Rules" (November 1959 and repeated in January 1960). The editors have been happy to send out reprints and/or give permission for others to reproduce.

A process engineer with American Oil Co. in Yorktown, Pa., said he wanted enough copies to "send to my state and national representatives."

Pacific Pumps, Inc., Huntington Park, Calif., asked for 50 copies declaring "we think this is a very good article."

The Kansas Paint & Color Co., Wichita, thought "it describes what is happening to a large extent in America" and asked permission to reproduce further copies for distribution.

Modern Engineering Co., St. Louis, said "it sure stresses the point" and requested 125 copies, one for each of its employes.

Mobil Oil Company's East Chicago refinery asked for 50 reprints which were directed to the Employe Relations Department and Ashland Oil & Refining Company's Research and Development Department, Ashland, Ky., asked for and obtained six copies of what they called "a masterpiece."

PETROLEUM REFINER will be glad to mail free copies of this editorial to anyone in the industry. Address Editorial Director, Box 2608, Houston 1, Texas.

and One More!

To the Editor:

I enjoyed very much the editorial on the poker game in your January issue of PETROLEUM REFINER, and would appreciate your passing on my request for two or three additional copies.

John T. Barr

John T. Barr
Escambia Chemical Corporation
Wilton, Conn.

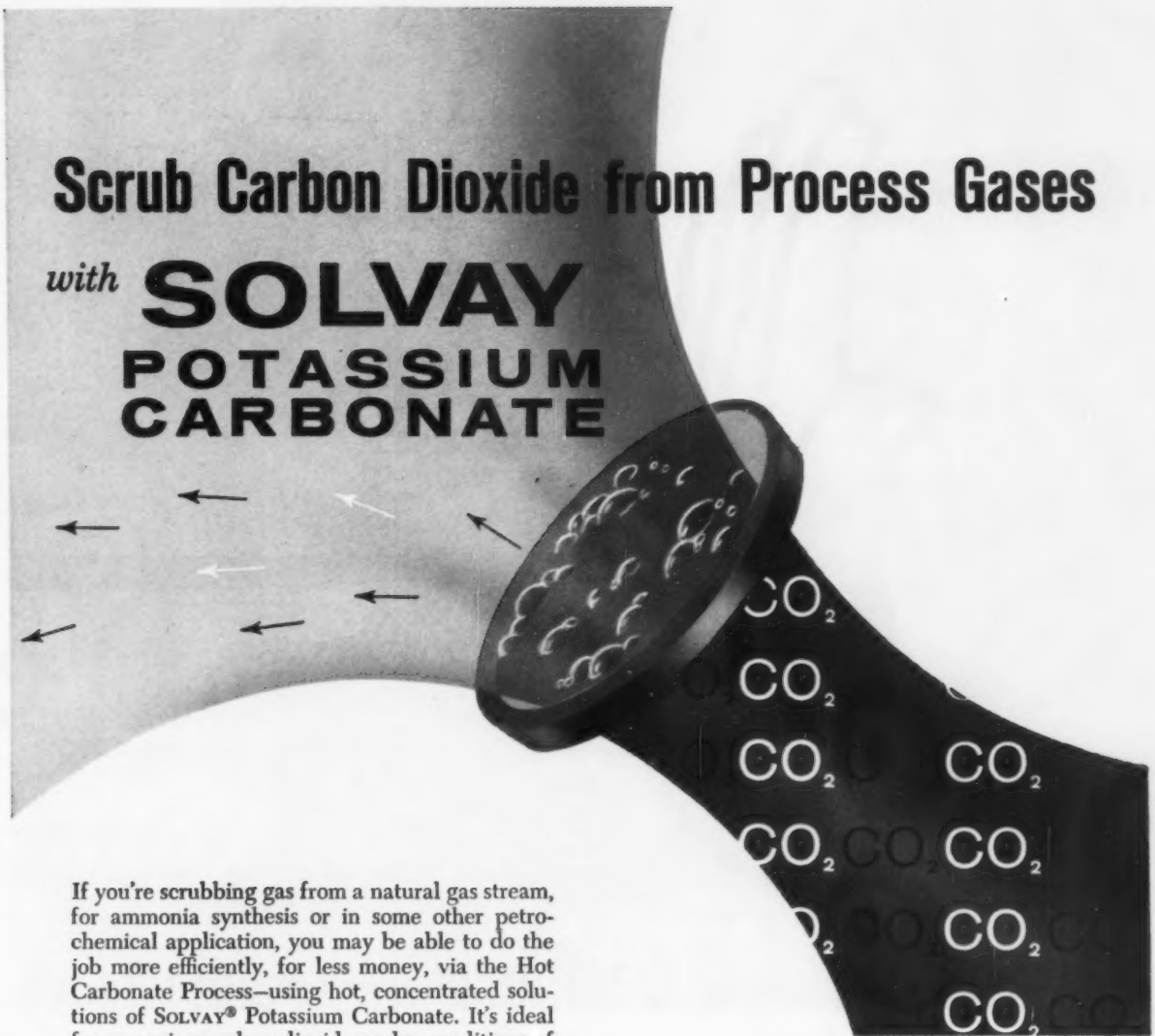
reminder:
see
SOLVAY
for
ALUMINUM CHLORIDE!

98% pure or better. Meets rigid chemical specifications. Available coarse screened, medium screened, fine screened, extra fine grind.

Used for producing detergent intermediates and other alkylates . . . isomerization . . . polymerization . . . varied Friedel-Crafts syntheses.

Scrub Carbon Dioxide from Process Gases

with SOLVAY POTASSIUM CARBONATE



If you're scrubbing gas from a natural gas stream, for ammonia synthesis or in some other petrochemical application, you may be able to do the job more efficiently, for less money, via the Hot Carbonate Process—using hot, concentrated solutions of SOLVAY® Potassium Carbonate. It's ideal for removing carbon dioxide under conditions of fairly high concentration and partial pressure from process gases.

You save over other methods because the circulating carbonate solution is used hot. This eliminates costly heat exchangers and reduces the process steam requirement.

To help you compare the hot potassium carbonate method with other gas-scrubbing processes, mail the coupon for any of the six authoritative articles from major chemical and petroleum publications or the booklet, "SOLVAY Potassium Carbonate."

Sodium Nitrite • Calcium Chloride • Chlorine • Caustic Soda • Chloroform Caustic Potash • Potassium Carbonate • Sodium Bicarbonate • Soda Ash Monochlorobenzene • Para-dichlorobenzene • Ortho-dichlorobenzene Ammonium Chloride • Methylene Chloride • Carbon Tetrachloride • Vinyl Chloride • Methyl Chloride • Ammonium Bicarbonate • Hydrogen Peroxide Snowflake® Crystals • Aluminum Chloride • Mutual® Chromium Chemicals Cleaning Compounds

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SOLVAY branch offices and dealers are located in major centers from coast to coast.

SOLVAY PROCESS DIVISION ED-30
ALLIED CHEMICAL CORPORATION
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Please send me without obligation the articles checked:

- ☐ "For bulk removal of acid gases . . . Costs Favor Hot Carbonate Process"—Chemical Engineering.
- ☐ "CO_2 Removal from Natural Gas"—Oil and Gas Journal.
- ☐ "Economics of Acid-Gas Removal"—Oil and Gas Journal.
- ☐ "Improved Process for CO_2 Absorption"—Chemical Engineering Progress.
- ☐ "Which CO_2 Removal Scheme Is Best?"—Petroleum Refiner.
- ☐ "SOLVAY Potassium Carbonate" fact book.
- ☐ **Aluminum Chloride data (see facing page).**

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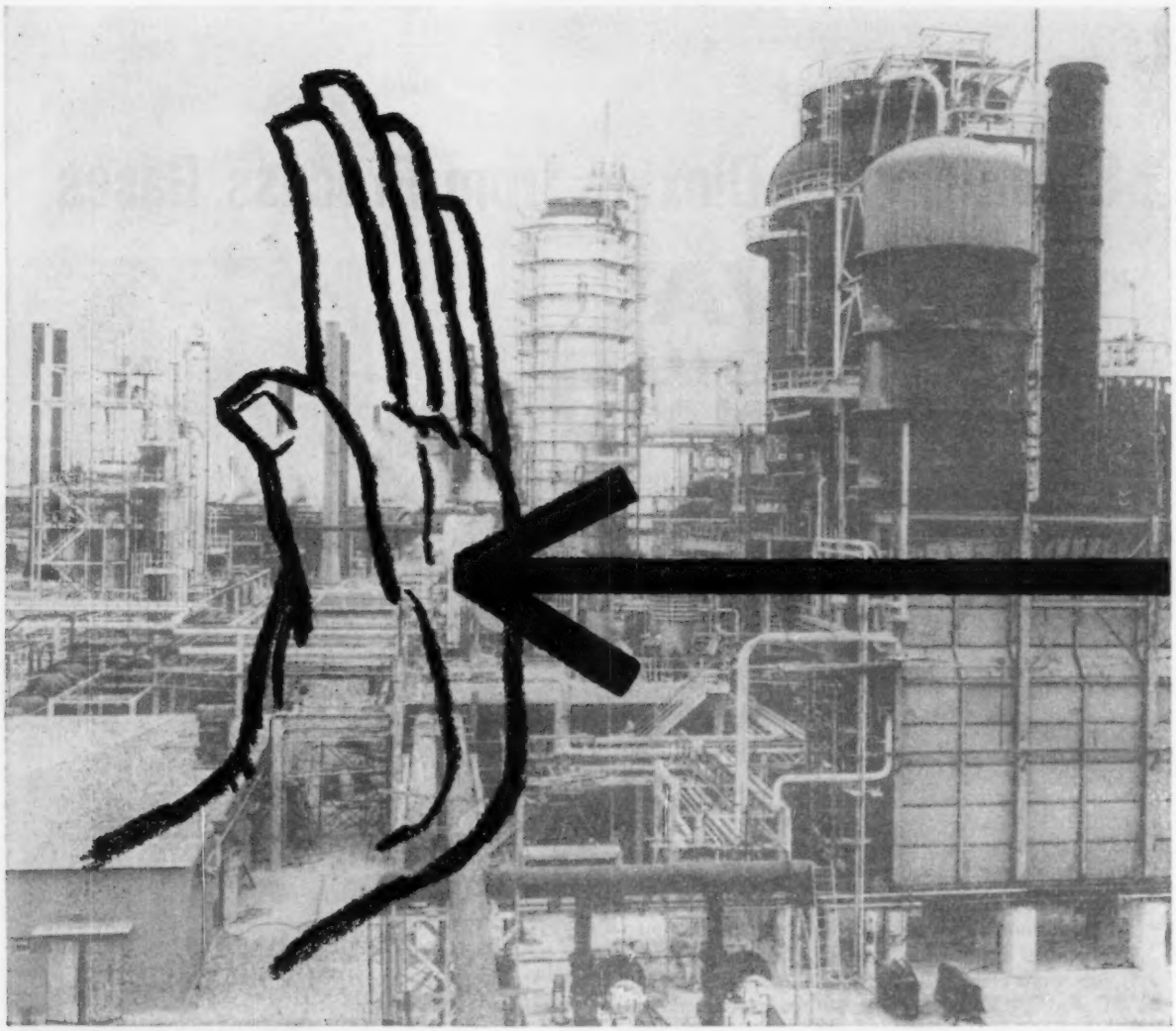

STOPS LEAKAGE!

. . . another virtue of ductile iron* Stanco Valves

Because ductile iron has a metallographic structure which resists leakage or seepage by liquids or gases, Stanco Valves made with this remarkable material are *pressure tight*.

But that's not all. They have thermal shock resistance equal to valves of cast carbon steels. Elevated temperature strength comparable to valves of cast steels. Corrosion resistance equal to valves of cast iron.

It all adds up to a story that's highly interesting to refinery engineers — a story with an exceedingly happy ending when the specifications get down to prices.

Whether your needs call for a production valve from Standard's broad line, or a special valve designed to your specific requirement, we think it will pay you to talk it over with people who are in the valve business from pattern making to testing. That's Stanco, of course.

* Trade Mark of the International Nickel Co.

SEE OUR CATALOG IN REFINERY CATALOG

STANDARD BRASS & MANUFACTURING CO.

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DISTRICT SALES OFFICES:

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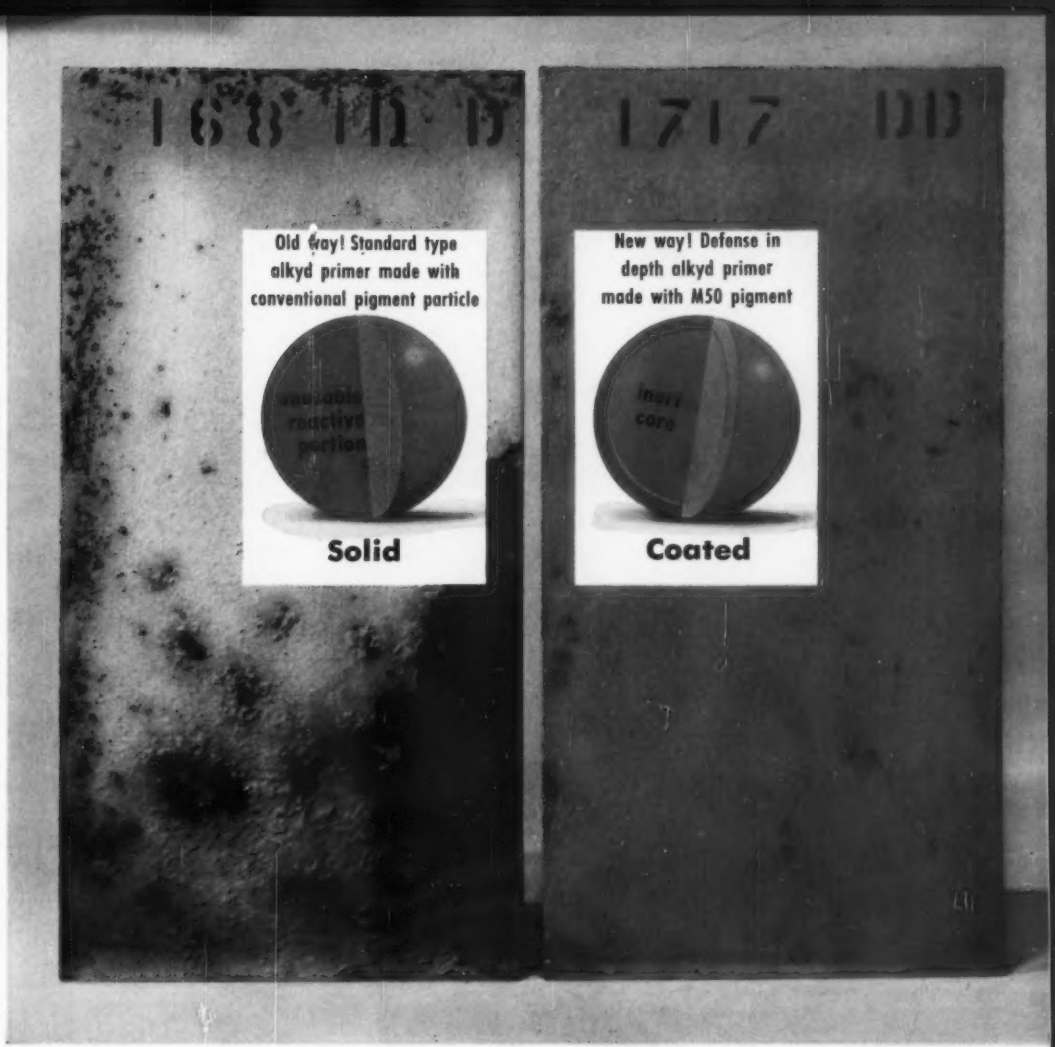
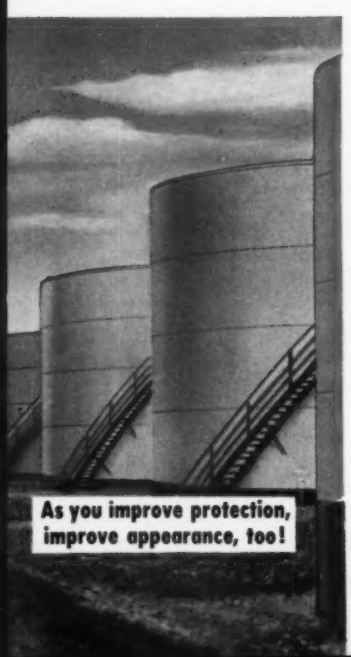
LOUISIANA: New Orleans — 4701 Palmetto • Shreveport — 2135 McCellan • Lafayette — 819 Oak Avenue
Corpus Christi — IBM Building • Baton Rouge — 3160 Florida

Never before such durable tank protection


Old way! Standard type alkyd primer made with conventional pigment particle
Solid
New way! Defense in depth alkyd primer made with M50 pigment
Coated

Proof tank paints with M50® pigment form rust-inhibitive films of outstanding strength and durability



Test panels like these *prove* what paints can do. And these two make it plain that paints containing *M50* basic lead silico chromate—a new National Lead rust-inhibitive pigment . . . form outstandingly strong and durable protective films.

Excepting the pigment, both primers shown on the test panels contain the same ingredients. Both are applied (2.0 mils, dry) on rusted and mill-scaled steel (to increase test's severity). Both have been exposed 12 months in industrial atmosphere (Perth Amboy, N. J.) and 12 months in normal atmosphere (Sayville, L. I.) at 45° South. You can see the effect.

A striking difference! Yet film strengthening proves to be only one of many improvements that *M50* pigment makes in metal protective paints for steel tanks and structures. Now—with new *M50* pigment—your regular paint suppliers can provide metal protective paints with outstanding advantages:

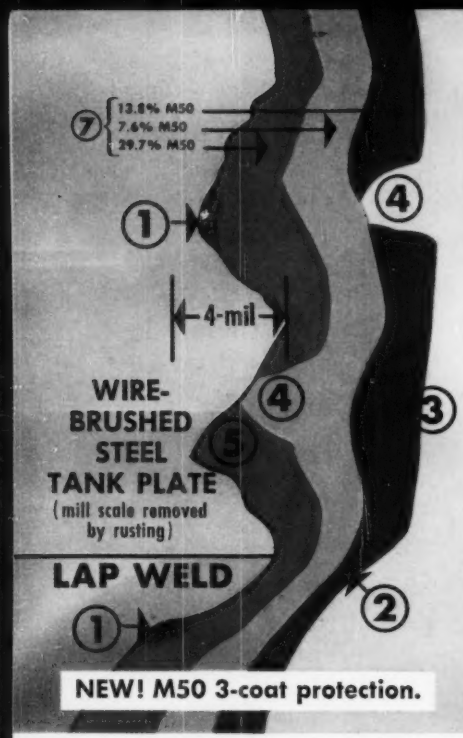
- Weather-resistant anti-corrosive primers.
- Intermediate and finish paints *with* exceptional rust inhibition but *without* bilging hazard in sulfur-laden atmospheres.
- Finish paints in a wide range of decorative colors that don't fade or wash out.
- Alkyd-type conventional and deep-coat paints with outstanding durability, package stability and sprayability.

What makes the difference? Basically the differences that make a difference in *M50* pigmented paints are inherent in the unique *M50* coated pigment particle itself (idealized particle shown above.) See, on the next page, the extra protections the *M50* particle provides in the dried film. See, too, how you can get the benefits of these new, much more durable, anti-corrosive paints.

M50 *an* **oncor** TRADEMARK *pigment development of*

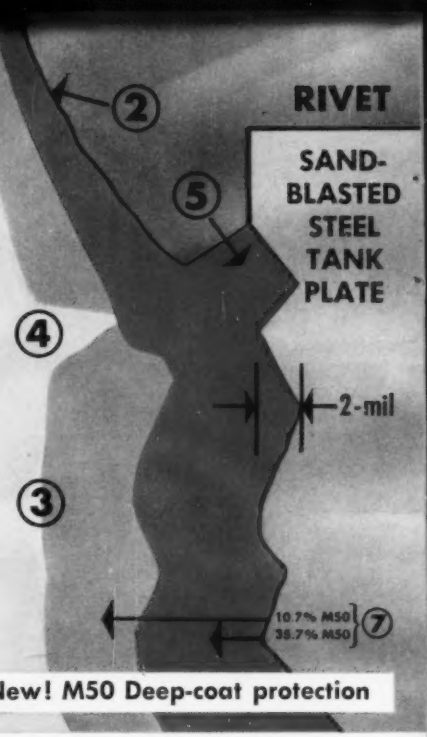
National Lead Company

111 Broadway, New York 6, N. Y.



NEW! M50 3-coat protection.

1. **Pockets of rust prove less harmful** on steel surfaces painted with conventional *M50* paints. Vehicles penetrate and isolate existing rust. *M50* particles stop rusting action.
2. **Where paint film lies thin** over tiny surface projections and sharp structural edges, the *rust-inhibitive* pigment content in all coats of *M50* paints provides extra protection.
3. **Just-right flow characteristics of** package-stable *M50* paints aid leveling on rough steel surfaces, promote smoothness, good appearance.
4. **Inevitable "holidays" in film** do not destroy protection. Again, *all M50* coats have both rust inhibition *and* weather resistance.
5. ***M50* paints "wet" well,** penetrate pits and crevices, carry *M50* protection to every part of these danger spots.
6. **Lightweight *M50* particle** aids formulation of new type deep-coat paints with *uniform* rust inhibition throughout the film and low sag characteristics.
7. **Every coat can have rust inhibition**—not just the primer. Note percentages of *M50* in dry films. What's more, for equal weights of corrosion-inhibitive pigment, *M50* primers contain 40-60% more corrosion inhibition by volume than non-*M50* primers.



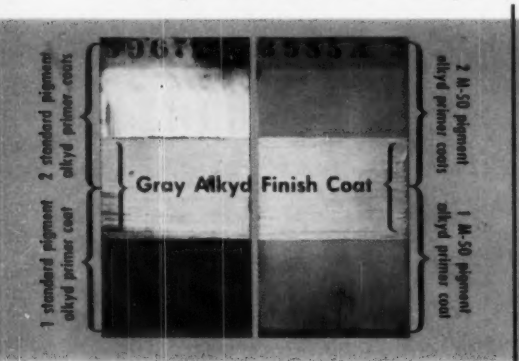
New! M50 Deep-coat protection

Sections through M50 Defense in Depth films show dramatic extra protection these new tank paints provide

Information on the preceding page proves that *M50* pigment paints form stronger protective films than anti-corrosive paints made with other rust-inhibiting pigments. The sections above show some of the ways in which these new paints perform better in the dry film. Below you will see *proof* that *M50* metal protective paints don't bilge, are unique for color stability and the color range in which they can be made.

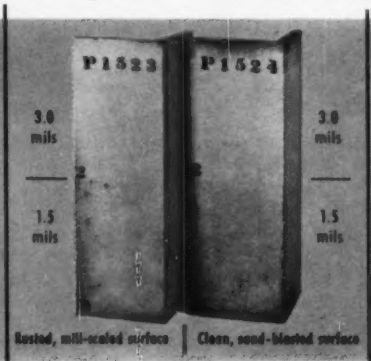
Hold the *M50* pigment particle itself responsible for all these improvements . . . *Basic lead chromate* is known for exceptional rust-inhibiting action. In the *M50* particle, this reactive business portion of the particle is coated on an inert core . . . where *all of it is available* to react. The coating is *fused* on—shows superior resistance to chalking, erosion, chemical action. Unusual tintability is due to the geometric configuration of the coated silica particle.

Why M50 Defense in Depth paints give anti-corrosion beyond all former concepts


2 standard pigment alkyd primer coats
2 M-50 pigment alkyd primer coats
Gray Alkyd Finish Coat
1 standard pigment alkyd primer coat
1 M-50 pigment alkyd primer coat

Exposed 9 years, 45°S. Each coat 1.5 mils

Proved corrosion and weather resistance



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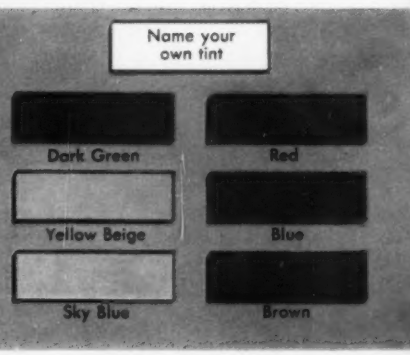

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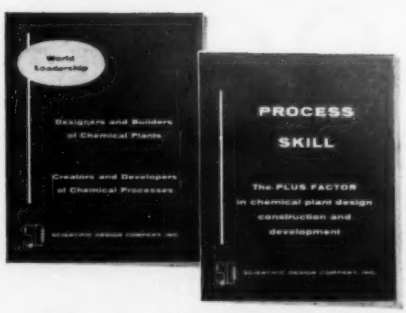
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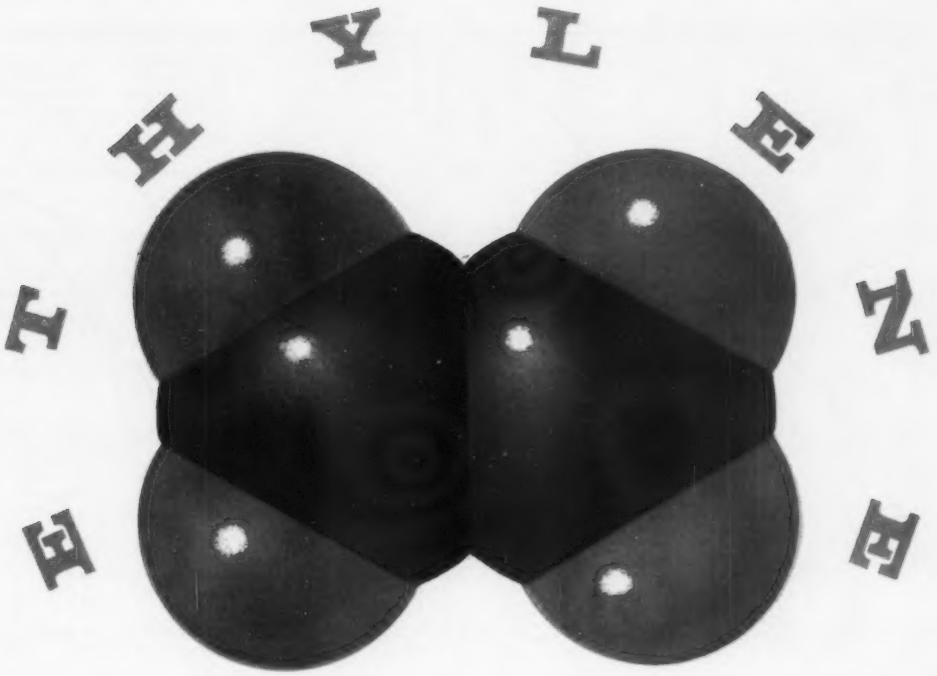

ETHYLENE TECHNOLOGY has grown with the same fantastic pace as ethylene production. First large commercial production was from refinery off-gases, supplemented by pyrolysis of suitable low molecular weight liquid hydrocarbons. Today, ethylene is made commercially from a wide range of petroleum materials including naphtha and heavy fuel oil.

This star petrochemical has influenced the entire industry. Here is a complete summary of ethylene uses, production and consumption patterns and technology—including cracking techniques, purification and separation methods, and commercial manufacturing processes.

ETHYLENE

. . . what you should know

C. H. Davenport, Monsanto Chemical Co.
Geneva, Switzerland

ETHYLENE—a star of first magnitude in the petrochemical sky—has had a profound effect upon the chemical industry in an amazingly short period of time. During the 1930's ethylene for chemical use was derived principally from by-product streams in petroleum refineries, and the chemical markets were for the most part ethyl alcohol and ethylene oxide.

However, like many another chemical having petroleum for an origin, ethylene first came into unusual prominence during World War II. The government crash program for the manufacture of synthetic rubber began in the early 1940s, with heavy concentration on the butadiene-styrene co-polymer. The large demand for styrene resulted in a correspondingly large demand for ethylene, so large in fact that new ways and means of producing ethylene had to be devised.

As a result of this trend initiated by styrene, and carried along immediately after the War by the impact of polyethylene, a whole new ethylene technology has been developed putting ethylene well out in front of all other

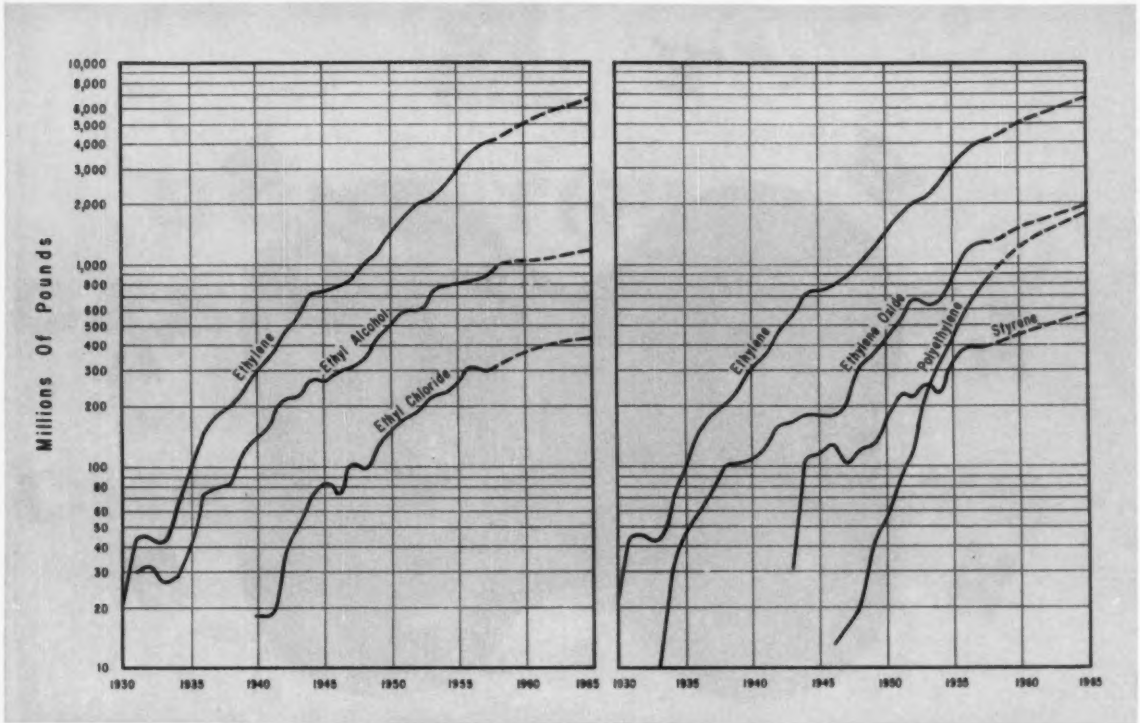

FIGURE 1—Shows the U.S. production of ethylene, as well as consumption of the olefin by ethyl alcohol, ethyl chloride, ethylene oxide, polyethylene and styrene from 1930 on and projected to 1965 to show what is predicted for the future.

petrochemicals (with the single exception of synthetic ammonia) insofar as annual tonnage is concerned. The significance of this remarkable olefin to our chemical economy can best be appreciated by reviewing the production, consumption, uses and technological aspects involved.

PRODUCTION AND CONSUMPTION

Much has been written describing the supply and demand picture for ethylene but a few comments here may be made to gain the proper perspective.[10, 13, 21, 26, 27, 28, 29, 33, 40, 41, 47, 48, 62, 76, 98, 181, 188, 199, 211, 213, 239, 241, 250, 285] In Figure 1, data are plotted to show the U.S. production of ethylene, as well as consumption of the olefin by five of its major derivatives. These data cover the period from 1930 on and have been extrapolated to 1965 to show what U.S. market analysts predict for the near future.

It is apparent that ethylene production has increased in remarkable fashion over the period shown, rising from about 300 million pounds in 1940 to some 4.15 billion pounds in 1958, with about 5.0 billion predicted for 1960, and even 6.5 billion for 1965. In other terms ethylene production (and consumption) in the U.S.A. has been growing at the rate of about 400 million pounds per year during 1955-60 and is expected to grow 300 million pounds per year during 1960-65.

It is interesting to compare the growth rate of ethylene with the rates for other major petrochemicals namely, synthetic ammonia, butylenes, 1,3-butadiene, petroleum benzene, propylene, and acetylene. Such a comparison is given in Figure 2. It is apparent that synthetic ammonia has occupied by a large margin the top position from a production standpoint over the period for which figures are available.

Ethylene, however, is very definitely in second place and has not been seriously challenged by any of the other hydrocarbons during the past decade.

Butadiene reached the second place position in 1945-1947 and acetylene (carbide plus petroleum-based) was second, and probably, first, in the early 1930s.

It is apparent that the predictions for the period 1958-65 call for significant increases in the production of ethylene, butylenes, petroleum benzene and propylene, but only slight gains for synthetic ammonia, 1,3-butadiene and acetylene. In fact, by 1970-75 there is a strong possibility that ethylene will surpass synthetic ammonia as the largest volume petrochemical.

Returning to Figure 1 it will be observed that over the entire 30 year period shown the growth rate curves for ethyl alcohol and ethylene oxide, as based on ethylene, are unusually similar, and a keen competition for ethylene has existed for these two compounds. Today ethylene oxide is in the lead and all indications are that such will be the case for some time to come.

A similar close parallel, at lower ethylene consumption, however, has existed since 1940 for ethyl chloride and styrene. After three post World War II plateaus in production, one during 1946-49, another during 1951-54, and more recently during 1956-58, the growth rate of styrene has been moderate and it is predicted to remain so through 1965. Ethyl chloride, on the other hand, has enjoyed a more stable growth over the years

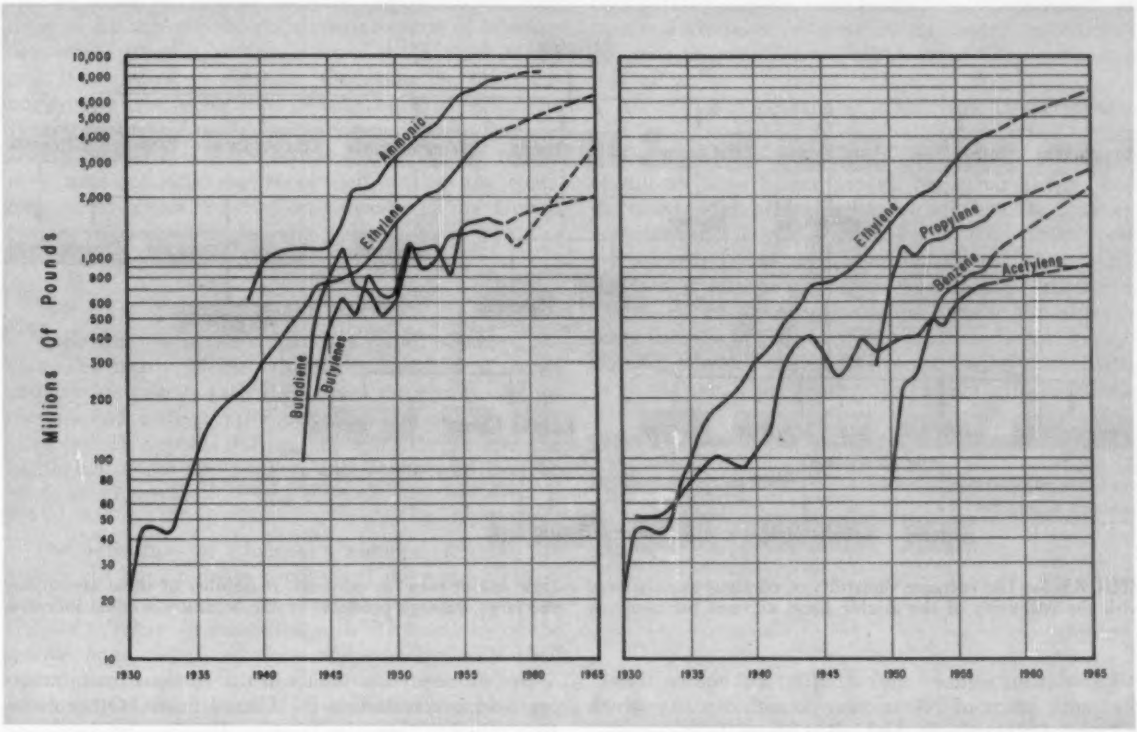

FIGURE 2—Compares the rate of growth of ethylene with the rates for other major petrochemicals—synthetic ammonia, butylenes, 1,3-butadiene, petroleum benzene, propylene, and acetylene. Notice that ammonia has occupied by a large margin the top position from a production standpoint over the period for which figures are available.

(due largely to its use in the steadily growing tetraethyl lead market) and it, too, is expected to show a moderate increase through 1965.

The extremely high growth rate of polyethylene is outstanding and predictions call for only slightly diminished growth through 1965. It is noteworthy that the ethylene consumption curve for polyethylene since 1955 has paralleled very closely, and even exceeded in slope, the production trend of ethylene itself. All the more remarkable is that the consumption of ethylene for polyethylene in the United States has grown from 6 million pounds in 1945 to 742 million pounds in 1957. By 1965 it is expected that the figure will reach nearly 1.8 billion pounds.

Further clarification of the production picture for ethylene and for the ethylene consumption of its five major derivatives noted above may be gained from Table 1. In this table actual annual figures in pounds are given for the period 1950-1958, as well as percentages of the total for each year for the various derivatives involved. Predictions for the period up to 1965 are also shown. The percentage figures are particularly enlightening.

As previously noted in Figure 1, polyethylene has shown a spectacular rise, accounting for only 4 percent of the total ethylene consumption in 1950, but rising to 22 percent in 1958, and having an expectation of 27 percent in 1965. In fact, in about 1967 it is anticipated that polyethylene will assume the lead as an ethylene consuming derivative, surpassing its nearest rival and present leader, ethylene oxide.

It will also be noted from Table 1 that the percentage figures for styrene, ethyl chloride, ethylene dichloride and total minor derivatives have been reasonably stable in growth since 1950. The high rate of growth of polyethylene has been accompanied by slower rates of growth for the other two major derivatives, ethyl alcohol and ethylene oxide.

The ability of the chemical industry to satisfy the huge ethylene requirements noted above has been demonstrated by the flurry of new construction during the 1950's. Plant capacity has kept well ahead of ethylene consumption but the spread is slowly narrowing. For instance, in 1954 the plant capacity for ethylene in the United States was about 3.5 billion pounds which was 43 percent greater than consumption; in 1958 the capacity amounted to 5.3 billion pounds representing an excess of 28 percent; in 1960 the figures are expected to be 5.85 billion pounds and 17 percent; and the predictions for 1965 call for a capacity of about 7.25 billion pounds, the excess over consumption being about 12 percent. This trend toward a balance between ethylene production capacity and consumption will continue, reflecting, as noted below, a levelling off in domestic U.S. production and a build-up of foreign production.

Major ethylene production capacity in the United States by mid-1959 (5.6 billion pounds) was confined to 18 companies with operations in 28 different plants. By 1965 it is expected that the production capacity will have increased by 1.65 billion pounds and that three new companies will have entered the field. One of these companies, Mobil Oil Company, already has its new

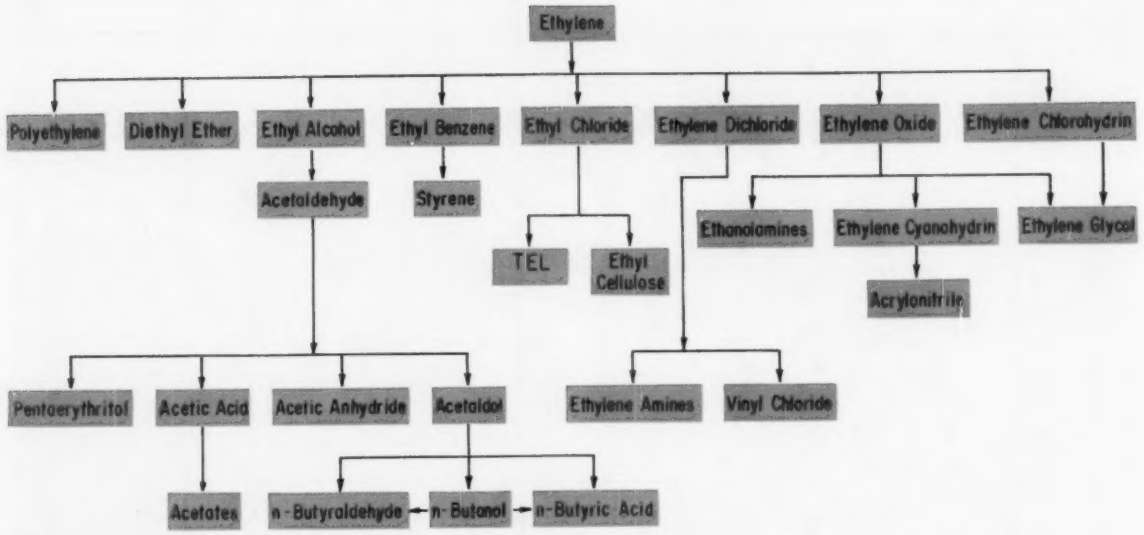

FIGURE 3—The extreme versatility of ethylene as associated with the reactivity of the double bond account for many of these major uses for ethylene. A number of these are among the large tonnage products of the organic chemical industry.

ethylene plant under construction at Beaumont, Texas, a gigantic plant of 380 million pounds capacity which will rank fifth in size in the United States.[46]

It is interesting to note that of the 28 ethylene plants in the country in 1959, 15 were located on the Gulf Coast in Louisiana and Texas. These 15 plants accounted for 66 percent of the ethylene plant capacity in the United States. And it is interesting also to observe that of the 1.65 billion pounds of additional capacity expected by 1965, 69 percent will be installed in the same two Gulf Coast states.

These figures are significant in that they reflect the abundance of cracking stocks available along the Gulf Coast (virgin material as well as by-products from petroleum refinery operations), the relatively low cost of such stocks, and the desirability of shipping ethylene derivatives to the major consuming areas of the Northeast rather than ethylene itself or the raw materials from which it is made.

Not all new construction in the ethylene manufacturing field is confined to the United States. Other countries, notably those in Western Europe, are becoming increasingly active.[15, 20, 34, 54, 56, 57, 58, 189, 305, 317, 318] Table 2 illustrates how the situation stood in 1957, compared with that in the United States.[189] It is apparent that the U.S. was far out in the lead, with the United Kingdom taking second place. It is also interesting to realize that a major fraction of the ethylene produced in the United Kingdom stems from the petroleum complexes recently completed, and now expanding, at Grangemouth, Scotland (British Petroleum Co.), and at Stanlow and Shell Haven, England (Shell Oil Company,) and at Fawley, England (Esso). In England, Imperial Chemical Industries has led the nonpetroleum companies in the manufacture of ethylene and has recently announced sizable increases in production capacity.[56, 57, 58]

Production of ethylene in all European countries is

TABLE 1—Consumption of Ethylene in U.S.A. (1950-1965)

Derivative	MILLIONS OF POUNDS OF ETHYLENE								
	1950	1952	1954	1955	1956	1957	1958	1960	1965
Ethylene Oxide	433	680	646	910	1130	1290	1280	1510	1950
Ethyl Alcohol	497	581	778	792	845	871	990	1050	1200
Polyethylene	55	115	320	440	593	742	907	1230	1785
Styrene	173	224	225	320	389	385	405	452	570
Ethyl Chloride	148	185	236	240	314	294	317	365	438
Ethylene Dichloride + Dibromide	160	235	262	180	196	250	250	280	322
Others				166	135	115	....	113	235
TOTAL (MM#)	1466	2020	2467	3048	3602	3947	4149	5000	6500
	Percent of Total Ethylene Produced & Consumed								
Ethylene Oxide	29	34	26	30	31	33	31	30	30
Ethyl Alcohol	34	28	31	26	23	22	24	21	18
Polyethylene	4	6	13	14	16	19	22	25	27
Styrene	12	11	9	10	11	10	10	9	9
Ethyl Chloride	10	9	10	8	9	7	7	7	7
Ethylene Dichloride + Dibromide	11	12	11	6	6	6	6	6	5
Others				6	4	3	....	2	4
TOTAL (Percent)	100	100	100	100	100	100	100	100	100

growing, and will continue to do so, as also will be the case for countries such as Australia, Japan, Canada and those of Latin America. As a result exports of ethylene derivatives to such countries from the United States may be expected to decrease. Consequently, plant capacity and new ethylene plant construction in the United States will, in the future, more nearly reflect the U.S. production and consumption of ethylene derivatives, with decreased exports of such to the major countries noted above. Production capacity in the United States will necessarily become more in tune with domestic ethylene consumption.

USES OF ETHYLENE

While the five major derivatives discussed above account for nearly all the ethylene manufactured today, end products from such derivatives are extremely numerous and have a marked effect on our chemical economy. It appears fitting, therefore, to review the highlights of the use picture, and reference may be made to Figure 3. [47, 48, 105, 130, 131, 143, 166, 212, 229, 248, 249, 259, 319]

The derivatives of ethylene, a number of which are among the large tonnage products of the organic chemical industry, owe their existence to the extreme versatility of ethylene as associated with the reactivity of the double bond. Thus, ethylene will combine with itself under special catalytic conditions to form solid polyethylene and the nature of the final product is very closely tied to the operating conditions used. Co-polymerization of ethylene and propylene is currently receiving much research attention and may lead to new types of polymeric products with a large volume demand.

Under acidic conditions ethylene will hydrate to produce, in the one case, diethyl ether, and in the other case, ethyl alcohol. The latter may be readily oxidized to acetaldehyde, which in turn is the starting point for a whole host of derivatives—acetic acid, acetic anhydride, the extensive acetate family, *n*-butyraldehyde and *n*-butanol, and pentaerythritol. Derivatives of *n*-butyraldehyde and *n*-butanol, such as butyric acid, 2-ethyl hexanol and their esters, represent a growing demand for the parent raw material, ethylene.

Should recently announced developments be commercialized concerning the Knapsack-Griesheim process[38a] for manufacturing acrylonitrile via the acetaldehyde-lactonitrile route, a brand new outlet for acetaldehyde, and possibly ethylene, will result.[38, 42, 50, 306] Recently announced German progress in the direct oxidation of ethylene to acetaldehyde could speed this development markedly.[51]

Alkylation of benzene with ethylene, in the presence of aluminum chloride catalyst, yields ethyl benzene which may be dehydrogenated to styrene. The impact of this on the ethylene growth curve has already been discussed. Hydrochlorination of ethylene is practiced commercially to give ethyl chloride, the starting point for tetraethyl lead and for ethyl cellulose. Direct chlorination is also practiced to give ethylene dichloride, the parent of the ethylene amine family and also of a large fraction of the vinyl chloride manufactured today. Finally, ethylene may be converted to the chlorohydrin or to the oxide, the former by reaction with hypochlorous acid, and the latter either by direct oxidation or by way of the chlorohydrin itself. Much has been published during the past few years on the direct oxidation of ethylene to its oxide and this route to the oxide is rapidly superseding the older course via the chlorohydrin. Both ethylene chlorohydrin and ethylene oxide are large volume starting materials for ethylene glycol production; the oxide, in addition, serves as the parent for the ethanolamines and for acrylonitrile as prepared by the cyanohydrin route.

TABLE 2—Production of Ethylene in 1957 in United States and Western Europe

	Millions of Pounds
United States	4,000
United Kingdom	550
West Germany	220
Italy	200
France	72
Others	Nil

There are many other, less major, uses for ethylene and several may be mentioned here. As a raw material for so-called C_6 alkylate, prepared by reacting ethylene with isobutane, ethylene stands a chance of entering a large volume, potential petroleum fuel market in the near future.[143] Finally, the recently announced higher alcohol process, developed by Continental Oil Company, involves polymerization, oxidation and hydrolysis of ethylene to low molecular weight liquid compounds (alcohols) using trialkyl aluminum catalysts.[45] This may become a major outlet for ethylene in a few years.

Technology

PROCESS DEVELOPMENT

Basic Considerations. When a hydrocarbon, whether it be a paraffin, olefin, naphthene or aromatic, is subjected to conditions of time and elevated temperature, a complex mixture can result with products covering a wide spectrum of molecular weights and type. The process is essentially one of dehydrogenation which, in general, is accompanied to some extent by polymerization and reactions between products to form ring structures of aromatic and olefinic classes. The lower paraffinic hydrocarbons give rise to rather simple product mixtures, but the complexity increases markedly as the feedstock molecular weight rises.

Thus, the thermal cracking of methane at high temperatures gives essentially acetylene, carbon and hydrogen, along with small amounts of acetylene derivatives such as bi-acetylene.

Ethane gives rise to ethylene, methane and hydrogen, the impurities being mainly carbon, acetylene and very small amounts of higher molecular weight oil.

Propane reacts in much the same manner, giving considerable propylene and ethylene along with such impurities as ethane, methyl acetylene and allene in the

product mixture. Also, production of by-product oils increases markedly.

Thermal cracking of *n*-butane extends the scope of the product composition still further in view of the production of highly reactive C_4 olefins and di-olefins. As the complexity of the feedstock is increased further, so is the complexity of the product mixture due, in part, to the greater number of components present and available for interreaction.

Process Conditions. The nature of the operating conditions has much to do with the conversion of feedstock and the composition of the product mixture. Temperature, of course, is a highly significant variable and probably the most important in pyrolysis reactions of this sort. Time at temperature is likewise important and can mean the difference at high conversion between securing say a high olefin yield or a high oil and (or) coke yield.

Pressure is also a variable in thermal cracking; elevated pressures appear to retard conversion to olefins and favor by-product oil production at the expense of the desired olefins. Hence, most thermal cracking operations for production of olefins on a commercial scale are handled at or slightly above atmospheric pressure, with some being carried out under sub-atmospheric conditions.

Finally, for given conditions of temperature, pressure and residence time, the nature of the products depends on the feedstock employed. Not all hydrocarbons crack with equal ease and in general less drastic conditions are required as the molecular weight increases. Thus, it is more difficult to crack methane than it is to crack ethane, ethane is more difficult than is propane or butane, kerosine, gas oil, and so on up the scale. Such is the case for paraffinic feedstocks.

Complicating the situation, however, is the fact that different types of compounds, even though they be of the same molecular weight, differ in the ease with which they thermally decompose. For example, in the case of C_6 hydrocarbons, the ease of pyrolysis and nature of product distribution varies depending on whether the compounds are paraffinic, naphthenic, olefinic or aromatic.[210] Thus, for a feedstock such as kerosine which is comprised essentially of paraffins, naphthenes and aromatics, thermal cracking is a highly complicated process involving a wide complex of simultaneous chemical reactions.

A large amount of basic research has been conducted over the years on the pyrolysis of hydrocarbons for the production of olefins and specifically for ethylene. Excellent bibliographies on early work in this area have been published by Lomax et al,[232] covering the period 1809-1915; by Egloff et al,[132] covering up to 1930; by Steacie[327] for the literature up to 1938; and again by Steacie,[328] covering progress in ethane pyrolysis up to 1955. The bulk of the effort in the pyrolysis field has been confined to the behavior of the lower boiling hydrocarbons ethane and propane, so abundant and generally available at prices attractive for large scale commercial operations.

Ethane has been studied extensively, particularly since it constitutes the simplest ethylene-source hydrocarbon and involves the simplest reaction mechanisms for dehydrogenation.[86, 87, 93, 103, 106, 108, 109, 115, 118, 120, 121, 122, 129, 136, 137, 152, 153, 154, 155, 157, 167, 168, 202, 208, 218, 220, 236, 267, 268, 281, 283, 284, 287, 291, 293, 297, 298, 312, 316, 320, 324, 329, 333, 335, 336, 337, 341, 344, 345, 352, 353, 354, 364, 365]

Propane pyrolysis studies have in many cases paralleled those using ethane, and the extensive literature is testimony to the effort that has gone into determining the effect of the various cracking variables, the mechanisms involved, and the analysis of the product mixtures.[83, 86, 87, 88, 89, 115, 121, 122, 126, 129, 134, 135, 136, 137, 140, 152, 153, 154, 155, 156, 157, 165, 167, 169, 202, 214, 217, 218, 220, 227, 236, 265, 267, 269, 281, 282, 293, 294, 297, 298, 312, 320, 332, 338, 342, 353, 354, 356]

During the past 30 years much basic research has been conducted in this country and also abroad on the pyrolysis of heavier feedstocks. Of these *n*-butane has received much attention and is currently a feedstock for ethylene in several plants in the United States.[86, 87, 88, 89, 104, 121, 122, 127, 128, 129, 134, 135, 136, 137, 139, 153, 154, 155, 156, 157, 162, 163, 164, 169, 170, 171, 174, 220, 227, 258, 265, 267, 269, 281, 282, 287, 293, 297, 298, 312, 320, 330, 339, 341, 342, 354, 356]

Isobutane has also been studied and, while not a desirable feedstock for ethylene, may be mentioned.[61, 121, 122, 129, 134, 135, 136, 139, 154, 162, 171, 180, 237, 265, 267, 269, 281, 282, 312, 331, 334, 340, 356]

Pentanes and hexanes, although not generally available as such for commercial ethylene plants in sufficient quantity and attractive price, have been studied and a number of articles have been published on the subject (for pentanes[87, 121, 129, 136, 151, 155, 163, 180, 255, 260, 281, 320 for hexanes.[87, 113, 114, 117, 121, 129, 136, 155, 163, 262, 266])

The use of even heavier feedstocks has gained momentum in recent years, particularly in Europe where the unavailability of ethane-propane-butane has forced consideration of the heavier materials. With such feedstocks the pyrolysis reactions become extremely complex and the process is characterized not only by the product ethylene but also by the generation of a number of by-products disposal of which at attractive prices can have a marked benefit on the over-all process economics.

Several ethylene plants in the United States employ relatively heavy feedstocks (e.g., field condensate, gas oil, heavy fuel oil, crude oil) and it is probable that the number will increase in the future as prices continue to rise for the simpler ethane, propane and butane now used so extensively. Many pertinent articles are to be found in the literature describing the pyrolysis of such heavier stocks as naphthas and natural gasoline,[54, 87, 113, 116, 117, 119, 129, 136, 165, 205, 228, 240, 270, 298, 344, 351] kerosine and gas oil,[70, 90, 92, 119, 153, 184, 185, 186, 190, 192, 205, 209, 227, 247, 275, 288] and even heavier feedstocks ranging up to crude oil.[22, 23, 25, 91, 178, 204, 221, 222, 223, 224, 225, 226, 227, 230, 231, 234, 261, 264, 272, 277, 295, 298, 315, 320, 344, 362, 363] Significant in this literature is the extensive work done by Linden et al at the Institute of Gas Technology, Chicago.[221-231] Even lignite has been investigated as a potential source of ethylene.[253]

As ethylene feedstocks the normal paraffins are more desirable than the other hydrocarbon classes, say olefins, naphthenes and aromatics, giving rise to higher yield and generally to fewer by-product complications. However, thermal cracking of these other classes has been studied to some extent, since such classes of compounds are often recycled in commercial operations and undergo thermal breakdown to some degree.

Propylene has received the greatest attention along this line and considerable information on its behavior during pyrolysis is available.[121, 122, 129, 134, 136, 152, 161, 170, 173, 177, 179, 254, 294, 348, 355, 368]

Butenes have likewise been investigated,[121, 122, 129, 134, 136, 170, 172, 175, 251, 252, 349, 355] also pentenes,[129, 136, 160, 170, 176, 252, 260] cyclic hydrocarbons such as naphthenes and cyclic olefins,[129, 133, 136, 156, 245, 270] and even aromatics.[129, 136, 235, 270] Butadiene yields appreciable ethylene during pyrolysis and its behavior has been reported.[136, 257]

No effort has been made in the present work to survey and list the multitude of patents in the thermal cracking field. The patent literature, particularly that of the United States, is a rich source of basic information in this area, covering production of ethylene (and other olefins) from a complete range of feedstocks (ethane to crude oil). In the process descriptions to follow it will be evident that the many processing steps involved, along with the modifications and alternatives, provide a fertile field for innovation and patent coverage.

Catalytic and Thermal Cracking for Large Volume Ethylene Production. As noted in the preceding discussion it has been recognized for many years that ethylene is one of many products formed when hydrocarbons are subjected to high temperature conditions.

Production of the olefin in large volumes first became a reality with the advent of catalytic cracking in petroleum refineries. It was not until the early 1930s that chemical uses were developed for this raw material which, up to that time, was disposed of by burning as fuel.

As noted earlier the rise of ethylene oxide and ethyl alcohol production in the early 1930s required rapid growth of ethylene production itself; much of this demand was met by recovering ethylene from refinery gas streams, as evidenced by the pioneering work of petroleum companies which let to the commercialization of ethyl alcohol production based on refinery feeds.

Today, a large fraction of petrochemical ethylene is recovered from refinery off-gas streams, particularly in the larger refineries, and disposal of such ethylene by burning as fuel is rapidly becoming a thing of the past.

Ethylene in refinery off-gases stems almost entirely from catalytic cracking operations. These operations are optimized for special fuel production (e.g., gasoline) and any ethylene generated is strictly a by-product. In view of this fact the ethylene yield is considerably lower than that which would be possible if the cracking operation were optimized around ethylene itself. The effect of catalysts on the cracking characteristics of hydrocarbons, with emphasis on ethylene production, has not been fully explored to date although some basic research is reported in the recent literature.[60, 70, 86, 90, 122, 126, 129, 136, 137, 152, 154, 158, 162, 163, 168, 170, 175, 179, 232, 346, 366]

Noteworthy is the fact that such materials as metallic copper, monel metal and chromic oxide have a marked accelerating effect on the cracking reaction and product distribution. It may also be pointed out that the ill-fated McCarthy chemical plant at Winnie, Texas, was designed for the catalytic dehydrogenation of ethane to produce ethylene;[73] also, the Catarole process which has seen commercial application in England, is said to employ catalysis for the promotion of aromaticity in the liquid product (see below). Mercury photo-sensitization of hydrocarbons has been investigated as a means of inducing decomposition.[83, 329] And, on the other hand, the effect of inhibiting agents, such as olefins, oxides of nitrogen, and others, on the decomposition of parafiins, has been studied.[109, 128, 180, 335, 336, 337, 338, 339, 340, 341, 342]

To meet the growing demand for ethylene it has been necessary to supplement the supply recoverable from refinery gases by installation of plants and facilities designed to crack feedstocks ranging all the way from ethane to crude oil. Such plants may be designed to handle specific feedstocks (e.g., ethane or propane) only but more often a flexibility factor is built in, making it possible for the plant to operate on a wide range of feeds. While such flexibility shows up in higher capital investment, considerable operating economy can often be realized by changing to low cost feedstocks as they become available. There are two important features characteristic of these plants for supplementing the ethylene supply:

1. The operation is optimized for ethylene production in nearly all cases, and hence ethylene is the product rather than a by-product.

2. The cracking operation is, in nearly all cases, thermal rather than catalytic.

Recovery of ethylene from refinery gases and from gases from the above thermal operations will be compared in a later section.

CRACKING TECHNIQUES

Pyrolysis Using Tubular Furnaces. Since the early basic studies on ethylene production from hydrocarbons involved use of a simple tubular device which was heated externally, it was natural that attempts to scale up to industrial size should involve the tube principle, with long single units or a multiplicity of tubes. Today, tubular furnaces for manufacturing ethylene are by far the most common and many articles have appeared in the recent literature concerning design of such equipment.[4, 72, 78, 80, 81, 94, 138, 187, 246, 271, 296, 297, 299, 300, 301, 322, 350]

Particularly noteworthy in this regard is the work of Schutt and associates.[296, 297, 299, 300, 301] Commercial designs of tubular furnaces are offered by several engineering-constructor firms.

While the tubular type of thermal reactor would appear to possess advantages in simplicity, construction and operation, it does have a number of limitations. First, pyrolysis of hydrocarbons, even of ethane, gives rise to some carbon formation. This condition is aggravated by use of very high temperatures, by long residence time at temperature, and by the presence of any hydrocarbon liquid phase at high temperature. As a result tubular cracking units should be designed, if possible, for use on completely vaporized feedstocks and for rapid passage at high temperature. The latter requirement calls for high heat flux furnaces, so designed

that the preheated feed can be brought to the desired cracking temperature in the shortest possible time, and then immediately quenched.

To counteract the conditions leading to carbon or coke formation in the tubes, commercial pyrolysis practice makes use of steam in the hydrocarbon feed. Steam serves a fourfold purpose in such an application:

1. It reduces the partial pressure of the hydrocarbon and permits complete vaporization of hydrocarbon before the highest temperatures are reached.

2. In reducing the partial pressure of the hydrocarbon, higher conversion of feed is obtained along with higher yields of desired olefin products.

3. The residence time of the hydrocarbon in the high temperature pyrolysis zone is lowered.

4. Steam assists in keeping the furnace tubes clean, having a scavenger action due to reaction of steam with carbon to form carbon monoxide and hydrogen.

The steam-to-hydrocarbon weight ratio generally used is in the range 0.2-1.0 pounds per pound, the lower value being characteristic for ethane and propane and the higher for say gas oil or heavy naphthas.

Pyrolysis of hydrocarbons is an endothermic operation and, in addition, the sensible plus vaporization heat loads are high. In the tubular furnace the hydrocarbon undergoes a temperature gradient as it passes through the tube. To steepen this gradient as much as possible—that is to bring the hydrocarbon up to the desired temperature as soon as possible—convection and radiation sections are incorporated into the design. The former, usually operating in the flue gas area, serves to handle vaporization and preheating, and the latter, in the furnace proper, serves to contribute the remaining sensible heat plus the heat of reaction. A very short time in the radiation zone is desired.

Obviously, the tubular type of furnace is not suitable for feedstocks having a high tendency to coke, in spite of added steam. Another limitation is the material of construction in the tubes which, depending on the feedstock used, can prevent attainment of sufficiently high cracking temperature to maximize the yield of ethylene. Alloys are normally employed and the maximum allowable temperature from a strength standpoint is about 850° C.

Pyrolysis by the Catarole Process. This process is a British development and has been pioneered on a large scale by Petrochemicals, Ltd., at Manchester, England.[6, 9, 96, 203, 289, 366] The process involves complete vaporization of hydrocarbon feed followed by thermal cracking at 20-50 psig. in alloy steel tubes arranged vertically in the radiant section of a furnace. The entire effluent then passes on to a reaction or "soaking" section wherein extensive aromatization occurs. This latter phase of the operation is conducted in the presence of metallic copper (packed tubes) at 630°-650° C. The low molecular weight hydrocarbons produced in the thermal cracking section are thereby very largely converted into aromatic compounds. Finally, the effluent is quenched with water to arrest the reaction. The light olefinic gases separated in the quencher are then passed on to a purification and product recovery section.

In the Manchester plant ethylene and propylene are recovered as such, along with many products from the by-product liquids. It is claimed that no unusual difficulty exists in obtaining pure aromatics from these complex liquid materials.

Pyrolysis Using Pebble Heaters. Mobil Oil Company has developed a thermal pyrolysis system involving the use of refractory pebbles as the heat transfer medium. Briefly, the system comprises two main elements, a heater and a reactor, the former directly over the latter and connected from bottom to top by means of a bucket elevator. Preheated pebbles from the heater section are introduced into the reactor where they contact the hydrocarbon feed. Thermal cracking occurs on the surface of the hot pebbles and any coke produced is deposited on that surface. The pebbles are then elevated to the upper heater unit wherein the coke is burned off by combusion with air and in the presence of burning fuel gas introduced directly into the heater. Heat produced in this operation is very largely absorbed by the pebbles which are then conveyed to the reactor section for the cracking reaction. This scheme, known as the TPC (thermofor pyrolytic cracking) process, has been thoroughly described in the literature by Eastwood and Potas.[123, 124, 125, 277, 314]

Phillips Petroleum Company has also developed a pebble heater process which is very similar to that of Mobil Oil Company. Here again two major vessels are employed namely, a preheater and reactor; refractory pebbles from the preheater are passed downward through the reactor and are then elevated back up to the preheater, in this case using an air-lift principle rather than a bucket elevator. Burn-off of coke from the pebble surface is accomplished in the preheater in essentially the same manner as used in the TPC process. The Phillips pebble process has been thoroughly described in the literature by Kilpatrick et al and by others.[31, 193, 194, 195, 196, 299, 304, 309, 312, 314] Employment of this process at very high temperatures for the simultaneous production of ethylene and acetylene has received considerable attention and has opened up new areas of development beyond the ranges possible for tubular-type pyrolysis equipment.

Another modification of the TPC process has been investigated on a pilot plant scale by the Surface Combustion Corporation, and has involved use of a moving bed of coke pebbles.[230, 233] A pneumatic lift principle was used instead of the bucket elevator and provision was made for withdrawal of both fine and oversize coke pebbles from the system.

Six main advantages are claimed for the TPC and Phillips pebble processes, as follows:

1. Wide flexibility with respect to the charge stock.

2. Efficient transfer of heat from the primary source to the hydrocarbon being cracked.

3. Rapid heating up of the hydrocarbon charge to high cracking temperatures.

4. Adaptability to the use of higher cracking temperatures than are permissible in tubular furnaces.

5. Continuous elimination of any coke formed in the reactor during cracking.

6. Ability to introduce charge stock into the reactor without the need for preheat.

Fluidized Sand Cracking. During the past year a number of articles have appeared in the literature relating to the use of a fluidized bed of sand as the effective thermal cracking medium. Outstanding in this area is the so-called Lurgi-Ruhrgas development, a result of cooperative effort in Germany between the Lurgi Gesellschaft, Ruhrgas AG, and Farbenfabriken Bayer AG Companies.[49, 53, 55]

In this process preheated feedstock is injected with superheated steam into a fluidized bed of hot sand which serves as a heat transfer medium. Any coke which results from the thermal cracking operation deposits on the surface of the sand particles and is burned off in a separate regenerator vessel. During the regeneration with preheated air the sand particles are heated up to a very high temperature and are then returned via a gas lift to the main reactor, thereby completing the cycle. This process has been worked out by the German companies through laboratory, pilot plant and now commercial scale operations. A new plant, recently built at Dormagen on the Rhine, has a capacity of 44,000,000 pounds of ethylene per year and is highly flexible with respect to the type of feedstock used.

The major advantages in the use of a fluid system such as the above are feedstock flexibility, adaptability to very high temperatures, ability to remove carbon readily from the reactor zone, recovery of heat in the burn-off operation, and efficient transfer of this recovered heat to the hydrocarbon in the reactor by direct contact with the fluidized sand. The process therefore permits use of high carbon-forming feeds which would be impractical to handle in conventional tubular furnaces.

An application of the fluidized sand principle to the thermal cracking of heavy crude oil has recently been described, employing continuous operation of a small pilot plant.[234] In this work, conducted by the National Research Council, Ottawa, Canada, no unusual difficulties were encountered and the process would appear to be readily amenable to scale-up. Somewhat similar work has been carried out at the Institute of Gas Technology, Chicago, and has involved use of fluidized silica gel, although other heat transfer media such as granular refractories, silica-alumina and coke breeze were stated to be satisfactory.[230, 277]

The use of fluidized coke particles as a heat transfer medium has been extensively investigated in Russia on a large pilot plant scale, employing both light and heavy feedstocks.[3] Circulating fluidized beds, as well as confined fluidized beds, were studied in this work and both were found suitable for the thermal cracking desired. A very recent announcement concerning the commercial process of Badische Anilin und Soda Fabrik (BASF) in Germany, using the fluidized coke principle, indicates the growing interest in this type of processing.[59]

Pyrolysis Using Regenerative Furnaces. The principle of regeneration, for heat transfer and conservation, has been applied to the manufacture of ethylene and to ethylene plus acetylene. A high degree of development has been attained in the so-called Koppers-Hasche furnace, which is very close in principle to the Wulff type of furnace for the manufacture of acetylene from low molecular weight paraffins.[142, 148, 165, 213, 360]

The process involves the use of two, rather elaborate, tile regenerative furnaces which operate cyclically. Air is preheated by passing through one of the regenerators, then is mixed with fuel gas and the mixture is burned in the second regenerator thereby bringing it up to operating temperature. The feed gas to be cracked is then cycled in reverse direction through the second regenerator and back through the first regenerator wherein sensible heat is stored up in the tile construction. An elaborate valve system for the cycling operation is employed.

It should be noted that this process does not involve the use of partial oxidation of the cracking feedstock, but it does require burning fuel gas in order to bring the system up to operating temperature.

Another characteristic of the process is that the composition of the product gas, and the conversion efficiency, vary during the course of the operating cycle; hence, published figures for composition and efficiency typical of the process must be interpreted as averages.

Modifications of the above regenerative scheme, particularly for the manufacture of high Btu fuel gas, have been reported, and a number are specific to the production of ethylene.[95, 215, 226, 230, 264, 278, 299, 343]

Autothermic Cracking. In this type of process the endothermic heat of cracking is balanced out by providing for combustion of a portion of the hydrocarbon feed with air or oxygen so that the over-all reaction is self-sustaining. This process was largely pioneered in Germany during World War II and involved the use of oxygen with ethane to produce ethylene. Since then a great deal of study has been made and reported in the literature for the autothermic cracking of a wide variety of feed stocks ranging all the way up to crude oil.

The most recent development in this area has been an atmospheric pressure process for the autothermic cracking of hydrocarbons in admixture with air, a process developed by the Universal Oil Products Company. The process operates at 1 atmosphere pressure as compared with the ½ atmosphere required for the German installation.

The question as to whether to use oxygen or air in autothermic processes is a matter of economic balance, the simpler purification system occasioned by use of oxygen being off-set by the cost of the oxygen plant required, and the low cost of the use of air being off-set by the added purification system needed for the removal of nitrogen. A number of articles relating to basic and applied technology on the subject of autothermic cracking for the production of ethylene may be found in the recent literature.[85, 111, 112, 147, 242, 274, 292, 314, 360]

An interesting modification of autothermic cracking involves the use of sulfur for dehydrogenation rather than oxygen. Work in this area concerning production of ethylene and acetylene from ethane has been reported.[256]

The simultaneous production of acetylene and ethylene, with emphasis on the former, has received considerable attention in recent years and autothermic cracking has been used to obtain the very high temperatures

required. Noteworthy is the literature on the SBA (Societe Belge de l'Azote) process,[30, 31, 36, 39, 43, 77, 263] on the Tennessee Eastman process,[1, 2, 31, 32] on the Phillips Petroleum Company "tangential" reactor process,[31, 44] on the BASF (Badische Anilin u. Soda Fabrik) technique,[37, 65] and finally on the Hoechst-Uhde development.[31]

Miscellaneous Pyrolysis Techniques. In addition to the various pyrolysis techniques noted above two others, specific to olefin production, merit brief description. One is the Tsutsumi process, developed in Japan, and which involves catalytic cracking of such heavy stocks as kerosine for production of olefins.[357, 358, 359] Special catalysts are used and the process has been developed using fixed bed and moving bed units. Highly aromatic oil by-products may be produced as desired depending on the operating conditions used.

A second novel technique is that which is practiced by Monsanto Chemical Company at Texas City, Texas, involving thermal cracking of propane by bubbling through molten lead.[140] In this case the pyrolysis is accomplished under conditions of very low residence time and essentially constant reaction temperature; coke formation is not a serious problem.

A third technique, developed by M. W. Kellogg and referred to later in the report, involves thermal cracking of heavier feedstocks using a heat carrier such as superheated steam. Thus, steam which has been superheated to about 925° C and higher, is contacted with preheated hydrocarbons and supplies the heat of vaporization and reaction plus a part of the sensible heat load.

MAJOR PURIFICATION AND SEPARATION TECHNIQUES

While the course of purification and hydrocarbon separation in ethylene manufacture has been variously reported in literature[63, 64, 107, 198, 219, 238, 286, 289, 302, 310, 370, 373] and will be discussed in some detail in the following sections, it appears pertinent to describe two major features at this stage—removal of acetylenic compounds and demethanization. Both have received wide attention in recent years and several processing alternatives for each are available.

Removal of Acetylenic Compounds. Removal of acetylenes from the process gas is a highly important step in the manufacture of poly-grade ethylene, the specification requiring that such acetylenes not exceed about 20 ppm in the finished olefin. Approximately the same limit exists for propylene meeting poly-propylene requirements. The exact position of the acetylene removal facilities in the purification and recovery sequence is somewhat of a variable throughout the industry. If it is desired to recover acetylene as such, then the facility may be placed at the end of the recovery system, with removal from the product ethylene being a last step in the process; otherwise, acetylenes and the higher di-olefins may be removed up-stream. The placement and type of acetylene removal facilities involve a number of factors, and an economic balance is often required to resolve the problem.

There are two major methods available for removing acetylenic compounds from ethylene-containing gases, one characterized by actual recovery of the acetylenes and the other by destruction of them. The former is usually applied to the product ethylene stream and constitutes final clean-up; acetylene is recovered as such and becomes a by-product for credit. Propylene may be treated similarly, but in this case the recovered acetylenes are seldom of value. The processing technique is one of absorption-desorption, using a selective solvent for the acetylenes such as dimethyl formamide.

In the second method a process of selective catalytic hydrogenation is employed, sufficient hydrogen being used to convert the di-olefins and acetylenes to mono-olefins. In fact, the operation can permit an increase of ethylene and propylene yields as a result. Such a technique is generally applied to the crude gas early in the purification sequence in order to take advantage of hydrogen already present in the gas stream. Numerous types of catalysts have been investigated and recommended for the selective hydrogenation, one of the current and most promising being a complex of nickel, cobalt and chromium on a rugged support.[280] It may be mentioned in passing that the Oppau process, developed in Germany during World War II but never commercialized, included a hydrogenation step for the selective conversion of acetylene in cracked gas (from ethane pyrolysis) to ethylene using a nickel oxide—chromium oxide catalyst.[307]

Both of the above methods for removing acetylenic compounds have been described and compared in recent literature.[52, 280, 307, 324, 325] The use of molecular sieves for this separation has been suggested and may become commercialized at some future date.[24]

Demethanization. The term "demethanization" is applied to the first step (usually) in the final product recovery sequence, and involves separation of methane plus hydrogen from the C_{2+} hydrocarbon components. In this case three alternative schemes are available and are practiced in industry.

The first method entails absorption at 450-500 psig and 70°-80° F, followed by desorption at 400-425 psig and 430°-460° F, using a highly aromatic oil from the pyrolysis reaction as the selective solvent. This oil is selective for C_{2+} compounds, the hydrogen and methane components passing through essentially unchanged. Various features of this method of processing have been described in the literature.[107, 207, 371, 372] An interesting modification may be found in the so-called Oppau process, already mentioned above.[307, 310] In this process an ethanolamine-copper nitrate solution was scheduled as absorbent for the ethylene produced by ethane pyrolysis.

The second method for demethanization, and one which has become most popular, involves low temperature fractionation. Through use of high pressures (400-600 psig) and extremely low overhead temperatures (—90° to —140° F) it is possible, with a low reflux ratio and only 20-30 trays, to obtain a high degree of elimination overhead of the hydrogen and methane. The proper design of a demethanization tower is a complex engineering operation, from a pressure-tempera-

ture and economic standpoint, and is aimed at minimum loss of ethylene overhead commensurate with minimum methane in the C_{2+} bottoms stream. A number of excellent articles have appeared in the recent literature on this important subject.[64, 74, 107, 141, 206, 243, 276]

A third technique for demethanization, known as "hypersorption," has been developed by Union Oil Company of California and has been described by Berg and others.[5, 66, 67, 68, 69, 71, 141, 149, 191, 303, 310] Briefly, the process involves adsorption-desorption, employing a moving bed of granular activated carbon as the adsorption medium. While this operation was considered successful, the hypersorption process has not been widely adopted in the United States due very largely, no doubt, to the extensive improvements brought about in demethanization by low temperature fractionation. It may be mentioned that the hypersorption process has been modified by Esso Research & Engineering Company to embrace fluidization principles; a "fluid char adsorption" (FCA) process has been the result.

Commercial Manufacture of Ethylene

Practically all ethylene produced in the world today results from recovery of the olefin from petroleum refinery off-gases and from thermal cracking operations as applied to a wide variety of hydrocarbon feedstocks. In passing mention may be made of a classical method for production of industrial ethylene namely, by the dehydration of ethyl alcohol using activated alumina as catalyst.[203, 375] That such a process is practiced at all may appear surprising, particularly in view of the previous discussion indicating that ethyl alcohol is one of the large scale outlets for ethylene. The anomaly may be explained by considering the properties of ethylene itself. Just as is the case with a number of other chemicals, notably acetylene, the physical properties of ethylene make for a difficult transportation problem, unless sufficient ethylene is involved to justify a pipe line. Hence, ethylene must generally be used near where it is produced. Ethyl alcohol provides a convenient, yet rather costly method, by which ethylene can be stored and shipped, for regeneration by dehydration at some site where ethylene is not available as such and (or) is required in small quantities. A typical example of such an application is in the manufacture of ethylene dibromide at a distant location from any ethylene pipe line.[35, 197]

Another unusual method for the commercial manufacture of ethylene, and which was actually used in Germany during World War II, involves the partial hydrogenation of acetylene. For such a purpose a catalyst comprising palladium on silica gel was employed,[203, 374] as also was another material of nickel-chrome composition.[75, 97, 145] Such technology reflected the shortage of hydrocarbons in Germany at that time, resort having to be made to synthesis of organics from inorganic starting materials (e.g., carbide).

Much has been written on the subject of ethylene manufacture, particularly in the last decade.[28, 79, 80, 81, 98, 144, 150, 159, 165, 166, 167, 182, 183, 192, 203, 244, 249, 250, 273, 276, 289, 290, 307, 321, 369] Noteworthy are series of articles by Schutt[298, 299, 300, 301, 302, 303] and by Sherwood,[308, 309, 310, 311, 312, 313, 314, 315] covering many aspects of the subject. A number of articles have been written covering performance of specific commercial ethylene plants; those describing the operation of the U.S. Industrial Chemicals Co. units at Tuscola, Ill., using ethane as feedstock,[19, 279, 326] the Phillips Petroleum Company pebble heater plant at Borger, Texas,[193, 194, 195, 196] using *n*-butane or ethane-propane as feed, and the Gulf Oil Corporation facilities at Port Arthur, Texas,[12, 99, 100, 101, 102] using ethane and propane as feeds, are enlightening. Reference should also be made to recent literature describing English and German installations where various grades of naphthas are used for cracking.[7, 14, 16, 17, 49, 53, 54, 55, 56, 57, 58, 200, 201, 317, 318]

Available process designs for the manufacture of ethylene by recovery from refinery off-gases or by steam pyrolysis of hydrocarbons all have one feature in common in that the ethylene plant is made up of three main parts, thus:

1. Cracking Section
2. Purification Section
3. Product Recovery Section

The nature of the feedstock and the end use for the ethylene dictate to a large degree the complexity and the capital investment required. Typical operations involved will now be described.

ETHYLENE FROM REFINERY OFF-GAS

Several commercial designs are available for recovering ethylene from refinery off-gas.[18, 31, 216] Figure 4 is a simplified flowsheet illustrating the major processing steps.

Cracking Section. When using refinery off-gas the major cracking facilities which give rise to the off-gas are, of course, part of the refinery investment and for this reason may be divorced from the ethylene plant considerations. However, as will be seen from Figure 4, the recovery of ethylene also leads to the recovery of ethane and likewise, if desired, to relatively pure propane. As noted earlier these two materials make excellent cracking stock for thermal pyrolysis to ethylene; consequently, if the ethylene demand from a particular refinery is high the situation can be met by providing additional cracking facilities specific to ethane and propane. Such an arrangement provides a complete ethylene "packaged" unit and, of course, up-grades considerably the ethane and propane by-products.

For cracking ethane and propane the furnaces are generally of the tubular type, as previously described. Upon leaving the furnace the cracked gas must be immediately cooled to arrest the chemical reactions taking place; such cooling is often referred to as "quenching." Each cracking furnace usually has its own quench system, particularly, as in this case, where different stocks are being cracked. The quench system may comprise a single spray tower into which the cracked gas is injected and immediately cooled by direct contact with a water

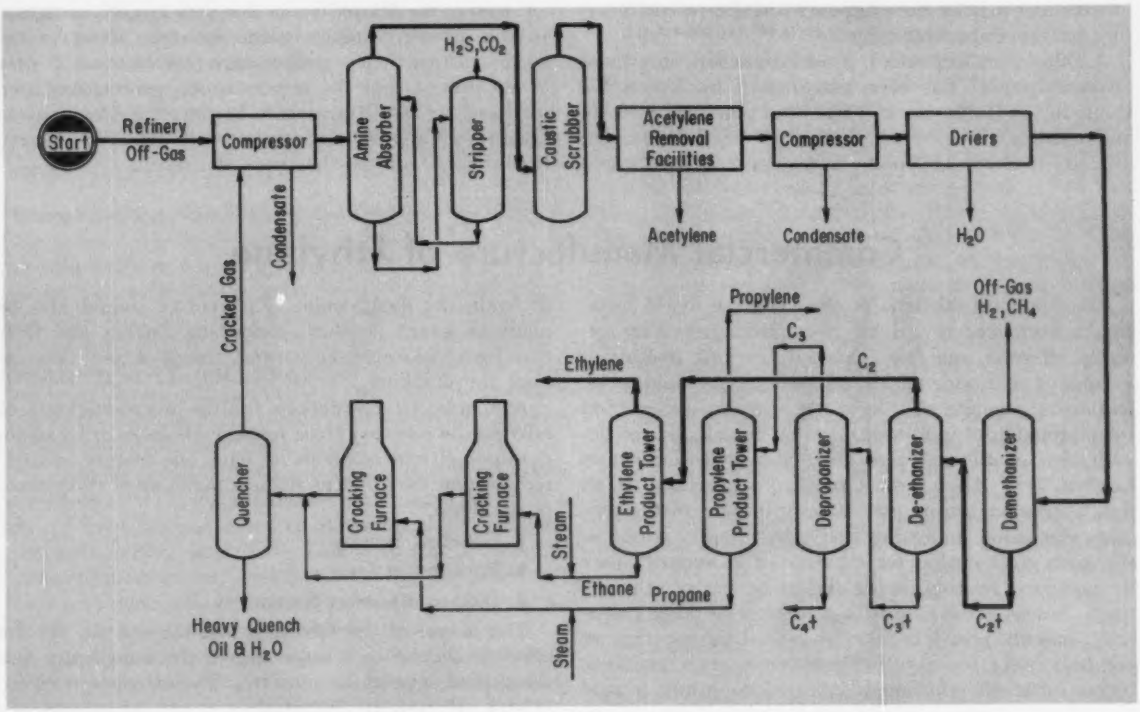

FIGURE 4—Typical scheme for manufacturing ethylene from refinery off-gas.

or oil spray stream. In such a system any heavy hydrocarbons present in the cracked gas are condensed along with steam and are withdrawn from the bottom of the quencher to an oil-water separator. Oil or water may then be recycled to the quencher sprays. Non-condensed gases from the quencher are taken off overhead. In some plants in-line quenchers are employed, with or without the above type of spray tower. In such a case, water or oil may be injected into the hot cracked gas as it flows from the furnace, followed by a separator for separation of water, oil and gas components. Usually, one or more indirect heat exchangers are included between furnace and separator, permitting generation of steam and pre-heating of furnace feed.

Purification Section. This section of the plant serves to remove extraneous impurities from the raw ethylene-containing gases prior to the separation of the major hydrocarbon components. Refinery off-gas, along with cracked gas from the quenching system described above, is first compressed in a multi-stage compressor, equipped with interstage coolers and liquid separators. The bulk of the heavy material in the feed, along with much of the C_4 fraction, is thus condensed and removed as liquid. Aside from facilitating compressor operation by removal of such liquids, the interstage cooling and removal reduce the tendencies toward polymerization which could lead to extensive fouling of the equipment.

Compressed gas, at say 100-200 psig, is next passed on to an ethanolamine absorption-desorption system, with succeeding caustic scrubber unit, for removal of the acid gases, carbon dioxide, carbonyl sulfide and hydrogen sulfide. Acid gas effluent from the desorber or stripper constitutes a raw material for further processing, such as production of elemental sulfur and sulfur-containing compounds. The caustic scrubber serves as a clean-up unit when used in conjunction with an ethanolamine system, and in some plants it alone is used if the acid gas concentration in the feed is low.

The clean gas from the scrubber is usually passed next through a vessel for the removal of acetylene, methyl acetylene, allene, as well as other higher acetylenes and di-olefins. This facility has been previously described and it was indicated that acetylenic and di-olefinic compounds could be removed as such or could be destroyed by a selective catalytic hydrogenation technique. The diagrammatic sketch shown in Figure 4 illustrates acetylene as leaving the clean-up facility as a separate stream; the implication intended is that acetylene is removed from the system, either as such or as a hydrogenated product.

Following further compression to 400-600 psig the cracked gas is chilled and passed through a battery of driers, each containing a solid desiccant such as silica gel or activated alumina, and serving to reduce the water content of the gas down to a very low level. Such driers are operated cyclically, regeneration of loaded desiccant being accomplished by periodic purging at about 400° F with steam or flue gases. Removal of water from the cracked gas is extremely important if

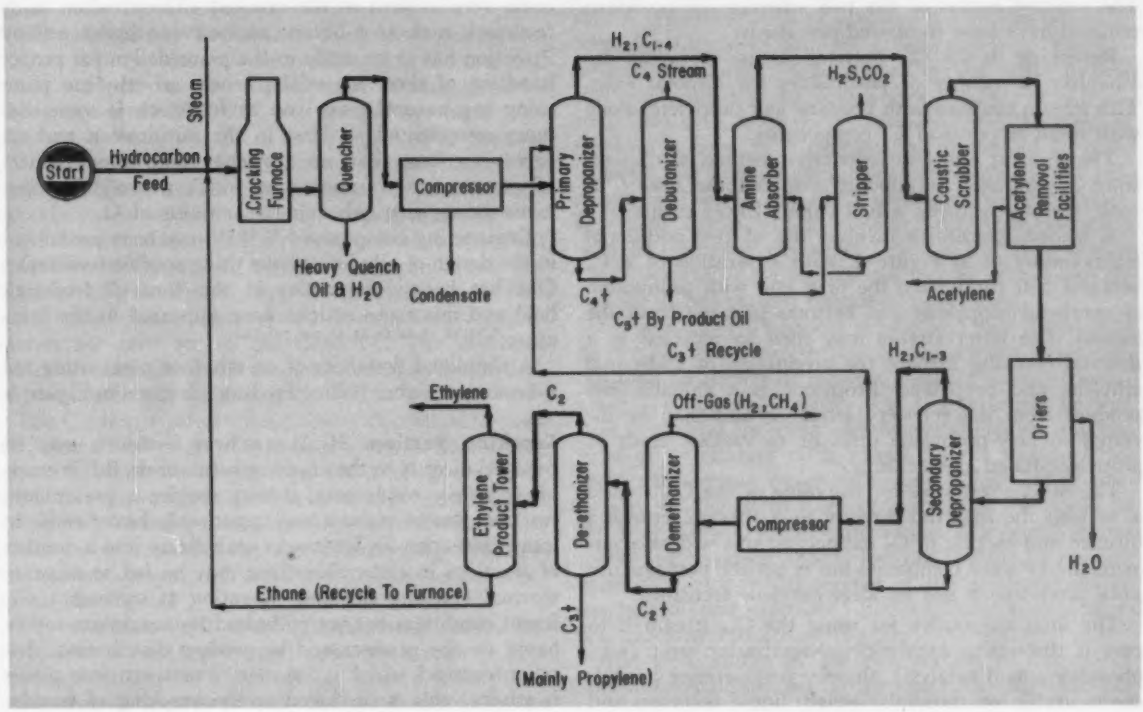

FIGURE 5—This typical ethylene plant uses a hydrocarbon feed such as *n*-butane. Heavier products may require a preliminary fractionation to remove non-vaporizable heavy ends.

solid hydrocarbon hydrates and also ice, with consequent plugging difficulties, are to be avoided in the succeeding low temperature fractionations.[82] Such removal of water to very low levels is a well-known and well-understood operation but its importance to the ethylene plant cannot be over-emphasized; it is a critical step in the purification scheme. In some plants a two stage drying system is used as a precaution, employing absorption-desorption with say triethylene glycol in the first stage to remove the bulk of the water.[102]

Product Recovery Section. From the driers the gas is cooled and then fed to the demethanizer, which has been described previously. This all-important unit—most often involving low temperature fractionation—serves to separate as precisely as possible the C_{2+} components from the overhead stream containing hydrogen and methane. The latter is nearly always used for fuel after suitable heat exchange for recovery of its refrigeration value. While not shown in Figure 4 the heat exchange requirements in such an ethylene process scheme are an important factor in plant design and operating efficiency. Since all the fractionators in the recovery sequence are characterized by low temperature overhead conditions, elaborate heat exchange between the feeds and product streams is utilized to handle the thermal requirements.

It should be pointed out that while demethanization is usually the first step in the final recovery scheme, process modifications do exist in some plants. For example, a de-ethanizer may be used first, taking off as overhead a C_2 and lighter stream which may then be fed to the demethanizer.[216] Such a practice reduces, of course, the load on the demethanizer and isolates it to some extent from process upsets.

The C_{2+} bottoms stream from the demethanizer is next fractionated in a de-ethanizer, whereby the C_2 fraction is taken overhead and the C_{3+} is removed as bottoms. This column, containing 30-40 trays, is generally operated at 200-400 psig, and with an overhead temperature of 0 to —10° F.

The C_2 overhead from the de-ethanizer is directed to an ethylene product tower which resolves the feed into an overhead stream of relatively pure ethylene and a bottoms of essentially ethane plus small amounts of ethylene. The bottoms provides excellent cracking stock for the supplementary cracking furnaces noted previously. The separation in the C_2 splitter is not an easy one and requires an extensive tower (50-60 trays). Operating conditions are generally 200-400 psig with an overhead temperature of about 0° F. Design features have been reported in the literature.[110, 146]

If no acetylene removal facilities are employed upstream in the process, most of the acetylene appears in the overhead ethylene stream from the above C_2 splitter; in such a case, if the ethylene is desired for polyethylene, the acetylene must still be removed by selective catalytic hydrogenation or by selective absorption-desorption (whereby it is recovered as a credit).

The relative merits of the two schemes for acetylene removal have been compared previously.

Returning to the C_{3+} bottoms stream from the deethanizer, a number of possibilities for disposal exist. This stream contains both propane and propylene along with small amounts of C_4 components.

The simplest and least expensive method of disposal from a processing standpoint is to sell the stream as such, thereby realizing a fuel value (LPG) credit.

A second alternative involves use of two additional fractionators as in Figure 4, with separation of a C_4 bottoms (for fuel) from the first, and with production of overhead propylene and bottoms propane from the second. The latter stream may then be recycled to a thermal cracking furnace for production of additional ethylene and propylene. Propylene is a valuable by-product from the recovery sequence and may be diverted to poly-propylene units or to various kinds of propylene-based chemicals.

The third alternative for disposing of the C_{3+} stream is to feed the material directly to a thermal cracking furnace and recycle to C_3 extinction; this is done commercially by some companies but is not the best practice since propylene is not an ideal ethylene feedstock.

The final alternative for using the C_{3+} stream is to pass it through a catalytic polymerization unit (e.g., phosphoric acid catalyst), thereby polymerizing propylene to usable low molecular weight liquid polymers and freeing the propane for subsequent feed to the pyrolysis furnace. Liquid polymers of this type have long been known as so-called "poly-gasoline" blending stock and are today finding high volume use as detergent raw material.

ETHYLENE FROM PYROLYSIS OF SPECIFIC HYDROCARBON FEEDSTOCKS

To supplement the ethylene recovered from refinery by-product streams and at the same time permit non-refinery companies to enter the ethylene manufacturing field, thermal cracking of selected hydrocarbons has made its appearance on the petrochemical scene and has shown remarkable growth during the past 15 years. Thus, in Texas alone, there are now six large chemical companies producing ethylene (Union Carbide, Dow, Jefferson, Monsanto, Texas Eastman and Du Pont) out of a total of ten producers (others being Humble Oil, Gulf Oil, Phillips Petroleum and Shell Oil). Further, a sizable proportion of the ethylene production from the four oil companies mentioned is derived by cracking specific hydrocarbons such as ethane, propane and *n*-butane.

There are many different feedstocks that may be thermally cracked to give ethylene as has been previously mentioned and, in fact, plants exist throughout this country and the world based on feeds ranging all the way from ethane to crude oil. Which feed to use is a matter of economics, being governed largely by hydrocarbon availability and, to some extent, by the market for concomitant by-products.

While the by-products will be reviewed briefly in a later section, it is important to note at this stage that C_4 by-products as well as C_{5+} liquid by-products become very evident in the cracked effluent when using feedstock such as *n*-butane or heavier hydrocarbons. Provision has to be made in the plant design for proper handling of these materials; hence, an ethylene plant using say natural gasoline as feedstock is somewhat more complicated, at least in the purification and recovery sections, than an ethylene plant using refinery off-gas streams containing up to C_3 as major components along with only minute amounts of C_4.

Engineering companies [8, 11, 31, 54] have been prominent in the design of ethylene plants using specific feedstocks. One has been quite active in the "heavy" feedstock field and numerous articles have appeared in the literature.[7, 14, 16, 17, 54, 56, 57, 58, 200, 201, 205]

A simplified flowsheet of an ethylene plant using say *n*-butane or higher boiling feedstock is given in Figure 5.

Cracking Section. Hydrocarbon feedstock may be pumped directly to the cracking furnaces or, if it is crude oil or heavy condensate, it may require a preliminary fractionation to remove non-vaporizable heavy ends. In some cases complex feedstocks are split up into a number of fractions in order that these may be fed to separate thermal cracking furnaces operating at somewhat different conditions but yet optimized for maximum return based on the product and by-product distribution. Another feedstock which is common to most ethylene plants is ethane; this is produced in the cracking of heavier feeds and it is general practice to recycle it back to cracking, using specific furnaces for the purpose.

As has been noted earlier, tubular furnaces are most commonly used although, with the current interest pointing toward heavy feedstocks, newer type furnacing techniques are beginning to receive serious attention. The limitations of tubular furnaces, especially with respect to the temperatures that may be practically maintained and to coke formation, become serious factors when considering heavy feedstocks. While steam is shown as joining the feed stream in Figure 5, suggesting a tubular-type of furnace, other types of furnacing may be used where steam is not required.

The quenching step previously described for the ethane and propane pyrolysis furnaces when recovering ethylene from refinery off-gases is equally important when cracking heavy feedstocks. Of course, the oil condensed is greater in volume and the equipment has to be sized larger.

Purification Section. As is the case with refinery off-gas, the first step in cracked gas purification is multi-stage compression, usually to 100-200 psig, and employing inter-stage coolers and separators. Considerable liquid is recovered as condensate at this point and in many plants it is pumped forward to join the main bulk of oil recovered in a subsequent step (from the debutanizer).

At this stage of the process it is customary to pass the compressed gas into a topping column, or primary depropanizer, which serves to take C_3 and lighter components overhead along with a small fraction of the C_4 materials, the latter being recycled back from the secondary depropanizer. The course of purification of this

overhead stream for removal of hydrogen sulfide, carbon dioxide, acetylenic compounds and water, is identical with that described for Figure 4.

Product Recovery Section. In the present process the primary depropanizer may be considered as the first step in the product recovery sequence. In this fractionator, with a pressure of 100-200 psig and an overhead temperature of 40-60° F, C_{4+} is easily removed as bottoms and the above-noted C_4 and lighter stream is taken off overhead. The latter, after purification, is passed to the secondary depropanizer (100-200 psig and —20° to —40° F overhead), which serves to provide a clean-cut separation of C_3 and C_4 components, even at the expense of considerable C_3 appearing in the tower bottoms. Such bottoms are recycled to the primary depropanizer for recovery of contained C_4. The overhead from the secondary tower contains hydrogen and hydrocarbons up to and including C_3.

The C_{4+} bottoms from the primary depropanizer constitutes the feed to the debutanizer tower. This column, operating at about 50 psig and 100-120° F overhead, serves to remove C_4 as an overhead stream and C_{5+} as bottoms oil. In many plants compressor condensate from up-stream is reworked in the primary depropanizer-debutanizer system, and is recovered from the debutanizer in the C_{5+} oil.

The overhead light stream from the secondary depropanizer is next compressed and cooled prior to precise fractionation (or alternatively, selective absorption-desorption or hypersorption) in the demethanization unit. The same comments may be made here as in the previous discussion and, in fact, the entire remaining purification is practically identical to before. The only major differences are the absence of the C_4 components, thereby eliminating the need for a depropanizer, and the higher concentration of propylene in the C_3 stream, permitting withdrawal of the mixed C_3 stream as such for direct use in many applications. Of course, if 99+ percent propylene is required another fractionator is necessary to remove the small amount of propane.

TYPICAL YIELDS OF ETHYLENE AND BY-PRODUCTS

Table 3 presents data illustrating the approximate yields in weight percent of feedstock for ethylene, propylene and by-product oil which are obtained when various feedstocks are subjected to thermal cracking in a tubular furnace. The data are given as ranges rather than specific figures since a number of variables associated with the cracking operation (e.g., temperature, pressure, residence time and steam-to-hydrocarbon ratio) have a distinct influence on ethylene and by-product yields.

TABLE 3—Yield of Ethylene, Propylene and Cracked Oil as a Function of Feedstock

Feedstock	YIELD (PERCENT BY WEIGHT OF FEEDSTOCK)		
	Ethylene	Propylene	Cracked Oil
Ethane	80—85	1— 2	Nil
Propane	44—45	15—20	5—15
n-Butane	32—35	17—22	6— 9
Natural Gasoline	27—30	12—16	25—30
Kerosine	24—28	12—15	30—35
Field Condensate	20—25	10—12	35—40
Crude Oil	6—17	6—12	30—40

The high ultimate yield (80-85 percent) shown for ethylene from ethane is significant, since very little by-product formation occurs. The 44-45 percent yield shown for ethylene from propane is also the ultimate, involving recycle of both the ethane and propylene by-products produced. As mentioned earlier in the discussion propylene does not constitute a good ethylene feedstock; however, with no propylene recycle the yield of ethylene is only 30-35 percent and a marked decrease in by-product oil production occurs. With further reference to Table 3 and to propane pyrolysis the propylene yield shown (15-20 percent) refers to operation with and without ethane recycle; the oil yield shown (5-15 percent) covers the conditions of ethane recycle and up to 100 percent recycle of propylene.

For the other feedstocks shown in Table 3 the yield figures are based on recycle of any ethane produced, but with no recycle of higher molecular weight components (i.e., C_3 and heavier). It is interesting to note that in general the yield of ethylene decreases, and the yield of by-product oil increases, as the feedstock increases in average molecular weight. The yield of propylene is affected to a lower extent for feedstocks in the propane-field condensate range. The yield figures shown for crude oil appear low but it must be remembered that only 40-50 percent of the crude oil charge can be fed (and vaporized) into a tubular type of thermal cracking furnace.

The yield values in Table 3 pertain to the use of operating conditions permitting long runs with relatively trouble-free performance. Through use of more severe operating conditions, particularly temperature, and using techniques such as fluidized sand or circulating pebble cracking, regenerative furnace pyrolysis, or autothermic cracking, ethylene can be generated from the heavier feedstocks in somewhat greater yields than shown in Table 3. Such an increase in ethylene production is accompanied by a decrease in propylene and butylene yields, as well as in cracked oil yield, and production of light gases, hydrogen and methane is increased.

The yield-temperature curves for ethylene, propylene and butylenes (as well as for other components such as 1,3-butadiene) show rather well-defined yield maxima. For propylene this maximum occurs at 780°-800° C. In the case of ethylene the greatest yield is to be found at 950°-1,000° C; for naphtha or natural gasoline pyrolysis this maximum is about 37 percent and the concurrent yield of acetylene is about 10 percent. At about 1,325° C ethylene yield is only 3-4 percent and acetylene yield is approximately 39 percent. Consequently, as will be noted in the next section, the most desirable temperature at which to pyrolyze a feedstock is governed by an economic balance over the whole operation, with the by-product yields playing a significant role.

Olefin yields, even at relatively constant temperatures, are dependent also to a great extent on time-at-temperature. Long residence times favor secondary reactions giving rise to higher molecular weight by-products (i.e., to increased oil production) at the expense of the lower olefins.

NATURE OF BY-PRODUCTS

In a previous section covering basic considerations of process development in the ethylene technology field it was pointed out that the by-products of hydrocarbon

pyrolysis comprised light off-gas, acetylenes, ethane, propylene, butylenes and 1,3-butadiene, and C_{5+} liquid. The complexity of the feedstock dictates very largely the complexity of the by-products formed, although the severity of cracking also plays a significant role. Only feedstocks of C_4 magnitude and higher give rise to all the by-products just mentioned.

The light off-gas stream, liberated as such from the demethanization step, is very largely methane on a weight basis (remainder mainly hydrogen with small amounts of ethylene), and for that reason is generally used for fuel.

Acetylene, while a by-product, is not always recovered as such but usually is destroyed by selective hydrogenation to ethylene (see previous discussion). The economics of recovering such acetylene, say by absorption-desorption, are affected to some extent by whether or not a nearby acetylene market exists and by the nature of the available acetylene supply. Higher acetylenes such as methyl acetylene, and the related di-olefins such as propadiene (allene), are of no particular value in ethylene manufacture but they do cause complications with the purity of by-product propylene and hence are usually removed by selective hydrogenation.

Propylene is generally the most important by-product, credit-wise, in the manufacture of ethylene from propane and higher boiling feedstocks, including refinery off-gas. From propane pyrolysis the by-product C_3 stream usually contains 40-50 percent propylene with the remainder essentially propane; the pyrolysis of *n*-butane and higher boiling feedstocks leads to a much more concentrated C_3 by-product, containing 90-95 percent propylene. This latter material is, of course, a highly attractive starting stock for polypropylene manufacture.

Ethane is produced as a by-product when cracking hydrocarbons such as propane or higher. As noted previously, most ethylene plants separate this ethane from the ethylene and recycle it to the cracking furnaces, since it is excellent cracking stock.

The C_4 by-product stream, originating from pyrolysis of C_4 and higher hydrocarbons, is a valuable one and constitutes a substantial credit item in the plant economy. The stream is often disposed of by direct sale to butadiene producers, the latter extracting the prevailing 1,3-butadiene content and then further dehydrogenating the remaining butylenes to yield additional butadiene. The butadiene content of the C_4 stream may range from 20-60 percent by weight depending on the pyrolysis conditions and feedstock used; the remainder is made up of isobutylene and mixed *n*-butylenes. Obviously, the C_4 by-product stream has considerable potential as a chemical raw material.

The C_{5+} oil by-product is a highly complex mixture of predominately unsaturated hydrocarbons. It contains straight chain, branched and cyclic olefins and di-olefins, as well as mono- and poly-nuclear aromatics, with alkyl side chains to some degree. The actual composition of such oil varies with the pyrolysis conditions to a great extent, greater aromaticity resulting from increased severity (e.g., higher temperatures, lower steam ratio and longer residence time). Considerable literature has been published in this field. [84, 95, 122, 153, 209, 229, 294, 347, 366, 367, 376] Probably the greatest reported progress in the intentional production and utilization of "cracked" oil is that involving the Catarole process reported earlier; recovery of various chemical components from the complex, aromatic mixture is thus shown to be an industrial reality.

It should be pointed out that in most ethylene plants utilizing propane or heavier feedstock two major oil by-product streams are produced; one is the C_{5-10} (approximately) oil from the bottom of the debutanizer and the other is the C_{9+} (approximately) material from the quenchers. The yields of these streams increase with the use of heavier feedstocks (see Table 3, tubular furnaces); consequently, considerable incentive exists to develop new uses for the oils as such and (or) techniques for recovering chemical components from them. Lucrative outlets for the by-product oils can have a marked effect on ethylene plant economics, especially in this age of rising feedstock prices.

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About the Author

Dr. Charles H. Davenport is in charge of Monsanto Chemical Company's European Technical Office with headquarters in Geneva, Switzerland. A native of Revelstoke, B. C., he received B.S. and M.S. degrees in chemical engineering from the University of British Columbia and a Ph.D. in the same field at Massachusetts Institute of Technology. He graduated in business management from the Alexander Hamilton Institute. Before joining Lion Oil Company's Research Division in 1948 as senior group leader and acting manager of engineering research and process development, he was research chemical engineer with Standard Oil Development Company. He has also been chief engineer in research and development, and assistant director of research for the Plant Food Division of Swift and Company. Prior to his overseas assignment he was assistant director of research for Lion Oil Company Division of Monsanto. He became a naturalized citizen of the United States in 1948.

Better Cat Feed By Solvent Extraction

Why Treat Cat Cracker Feed?

The tendency of crude oil discovered in recent years to be more asphaltic and to contain more sulfur has been reflected in the characteristics of the cracking charge-stocks used in many refineries. This trend, coupled with the natural desire of refiners to make greater amounts of useful products from each barrel of crude, has directed interest toward various methods of improving the quality of catalytic cracking feed. Some processers have improved their vacuum distillation while others have used hydrogen pretreatment.

A third scheme is reported here. It involves extraction of the virgin feed to remove those materials which tended to make excessive quantities of coke.

Although many papers were published on the extraction of cycle oils,[1,2,3] treatment of virgin feeds received very little coverage. No information was found on the use of solvents other than furfural, or on the relative merits of solvent extraction compared to alternate processing schemes. Thus, two cracking feedstocks were treated with phenol to permit comparing the quality of the raffinate and the product distribution obtained upon cracking with similar unextracted stocks prepared from the same crude.

More gasoline is made during catalytic cracking when phenol extraction is added to the virgin feedstock pretreatment. These data show the improvement

Paul T. Atteridg and Robert P. Cox*
The M. W. Kellogg Company, Jersey City, N. J.

THE SUPERIOR QUALITY of a phenol raffinate gives production of 7 to 10 percent more gasoline when catalytically cracked. This finding was made by cracking two types of charges to the same carbon yields—one prepared by decarbonizing only and the other by decarbonizing plus phenol extraction.

The tests were made under severe extraction conditions in which about half of the oil was removed as extract. Calculation for more modest yields of extract show a phenol extraction unit for treating decarbonized oil can pay for itself in about two years after taxes.

Four Feeds Prepared. Crudes of Arabian and South American origin were distilled under vacuum and the residuum from each was subjected to solvent decarbonizing. Each reduced crude was decarbonized with a propane-butane solvent at two different temperatures to produce decarbonized oil in yields of about 25 and 43 percent.

Thus four different feeds were available—two from each of two crude sources. Yields and inspections of the vacuum residue and decarbonized oils are shown in Table 1.

Two Portions Treated With Phenol. Phenol extraction was carried out in a centrifugal extractor. This

TABLE 1—Decarbonizing of Reduced Crudes

	ARABIAN			SOUTH AMERICAN		
Stock Identity	Feed	A	B	Feed	C	D
Yield (Residuum Basis), Wt. %	100	22.8	40.5	100	26.6	46.0
Gravity-°API	6.9	19.7	17.7	6.8	20.3	18.1
Conradson Carbon, Wt. %	22.1	4.2	6.5	15.0	3.6	5.9
Aniline Point,°F.	.....	226	.....	.....	234	.....
Sulfur, Wt. %	4.0	2.0	2.5	2.6	1.4	1.8
Metals, ppm:						
Vanadium	102	1.32	3.81	365	4.97	12.4
Nickel	20.1	0.27	0.86	73.6	1.67	3.46
Copper	0.68	0.06	0.02	1.27	0.01	0.04
Iron	4.8	0.12	0.14	14.2	0.06	0.21

*Robert P. Cox is now with Aerojet-General Corp., Sacramento, Calif.

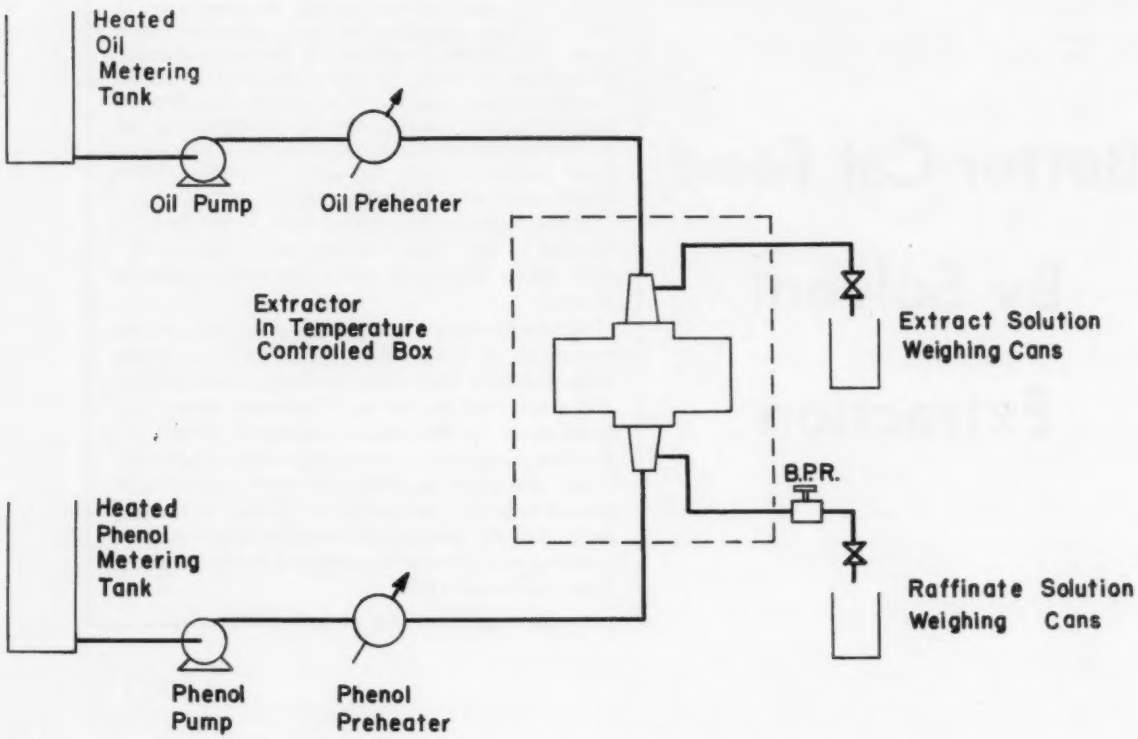

FIGURE 1—Phenol extraction was carried out in a centrifugal extractor.

machine consisted of a rapidly rotating cylindrical contactor equipped with perforated annular rings and a clarification zone at both the hub and the periphery. The intimate contacting during flow through the holes in the ring, followed by partial clarification between rings, provided several extraction stages; previous tests have shown that a machine of this type, when operated at design speed and with the proper flows and pressure balances, is equivalent to about 8 theoretical extraction stages.

Light liquid feed was introduced near the rim and flowed countercurrent to the heavy liquid solvent which was introduced into the body of the machine at one of three injection points between the rim and the hub. Raffinate product was withdrawn at the hub and heavy extract solution at the periphery.

A sketch of the solvent treating equipment used in these tests is shown in Figure 1. Raffinate and extract steams were freed of phenol by steam stripping in glassware prior to further testing.

The decarbonized oil prepared at the higher yield level from each reduced crude was extracted with molten phenol in a centrifugal extractor to prepare a raffinate having the same yield (basis reduced crude) as the low-yield-level decarbonized oil prepared from the same crude. Treatment was carried out with anhydrous phenol using a solvent ratio of about 2.5 and a temperature of about 200° F. Operation conditions are shown in Table 2.

A comparison between decarbonizing only and decarbonizing plus phenol extraction is made in Table 3. The properties of the raffinates were substantially different

TABLE 2—Phenol Extraction of Decarbonized Oil

Stock Identity	Arabian	South American
Feed Identy	B	D
Phenol/Oil, V/V	2.55	2.56
Charge Temp., °F	200	200
Raffinate Yield, Weight Percent		
Charge Basis	57.5	54.9
Reduced Crude Basis	23.3	25.3

TABLE 3—Comparison of Phenol Extraction

Stock Identity	Decarb. Only (A)	Decarb. + Phenol (Raffinate From B)	Decarb. Only (C)	Decarb. + Phenol (Raffinate From D)
Yield (Residuum Basis), Weight Percent	22.8	23.3	26.6	25.3
Gravity, °API	19.7	23.3	20.3	25.3
Conradson Carbon, Weight Percent	4.2	2.2	3.6	2.5
Aniline Point, °F	226	256	234	276
Sulfur, Weight Percent	2.0	1.3	1.4	1.0
Metals, ppm:				
Vanadium	1.32	0.57	4.97	2.57
Nickel	0.27	.....	1.67	0.87
Copper	0.06	0.60	0.01	0.46
Iron	0.12	0.22	0.06	0.25

from those of untreated oil even though yields (basis residuum) were about the same. In each instance, both the API gravity and the aniline point of the phenol-treated oil were substantially higher than the corresponding properties of the untreated oil. These changes reflect the greater paraffinicity of the raffinate which resulted from the selective extraction of polynuclear compounds.

Other differences are the lower carbon residue and lower sulfur content of the phenol-treated oils. All of these improvements were reflected in the product distribution and quality obtained upon subsequent cracking.

Note also the lower metals contents of the phenol-treated oils: the concentration of nickel and vanadium after phenol treating was about half that of the corresponding untreated oil. The contradictory increase in the concentrations of copper and iron were caused by pick-up of these metals in the extraction equipment where copper tubing and steel pipe, pumps and contactor were used. Although the cracking tests were too short to permit accumulation of much metals, in prolonged usage oil of low metals content would cause less catalyst poisoning and therefore better product distribution than oils more severely contaminated.

Cat Cracking Shows the Difference. Catalytic cracking tests were carried out in a reactor of one-liter capacity, containing 3/16-inch pellets composed of one-fourth fresh synthetic catalyst and three-fourths used cracking catalyst. The two components were mixed before pelleting.

The hydrocarbon feed was heated in a lead-bath preheater and charged to the reactor which was held at about 900° F. The cracked product leaving the reactor was cooled, the condensed liquid collected, and the gas metered and sampled. Tests were of one-hour duration from feed introduction to shut-off. All products made during this time were collected for analysis; any additional liquid obtained during the nitrogen blowdown of the unit was combined with the liquid product. To obtain different cracking conditions, oil feed rate was varied in some experiments; in others, the catalyst charge was reduced from the one-liter maximum and the void space filled with inert solids. A flow sheet for the cracking tests is shown in Figure 2.

The results of the cracking tests are shown in Table 4. Cracking results for extracted and unextracted feeds are compared in Figure 3 for the Arabian crude source and in Figure 4 for the South American crude source. In each figure the yields of carbon, dry gas, and C_4 + gasoline and the required severity factor are shown as a function of conversion. "Severity factor," a term used to measure the harshness of cracking conditions, is the catalyst/oil weight ratio divided by the weight hourly space velocity. In a one-hour test with non-circulating catalyst it is equal to (space velocity)$^{-2}$.

Comparison of the lines for phenol raffinate and decarbonized oil (deliberately drawn parallel to one another) shows phenol extraction produced superior cracking stocks; for a given conversion, more gasoline and less coke were made and lower severity factors were required when the feed has been phenol extracted than when it was merely decarbonized. Dry gas yields were the same for both preparation techniques.

Inspection and cracking data for a Mid-Continent gas oil and for one of the extracts prepared during phenol extraction are presented in Table 5. These data also are shown graphically in Figure 5. Extract cracking was done merely to demonstrate how poor it is; in practice, one would not choose to feed such material to a catalytic cracking unit.

The curves in Figure 5, if compared with those in Figures 3 and 4, show that phenol raffinate was a superior cracking stock to gas oil and that the materials removed by extraction and concentrated in the extract were grossly inferior materials for cracking. This is demonstrated by the summary in Table 6, where values of severity factor and yields of carbon, dry gas, and gasoline (read from Figures 3, 4 and 5) are shown for a constant conversion of 50 percent.

Extracted oils, while requiring only about two-thirds as much severity as unextracted oil, made about 3 percent less carbon and 2-3 percent more gasoline (both basis feed) than unextracted oils. Gas oil produced gasoline yields intermediate between those of decarbonized and extracted oils with carbon yields somewhat lower than either; the severity factor requirement for gas oil, however, was 2½ times that for extracted feed. Cracking of phenol extract resulted in lower gasoline yields

TABLE 4—Summary of Cracking Test Results

Feed Identity	ARABIAN							SOUTH AMERICAN				
	Decarbonized Oil A					Raffinate From B		Decarbonized Oil C			Raffinate From D	
Experiment Number	1	2	3	4	5	6	7	8	9	10	11	12
Operating Conditions:												
Average Catalyst Temperature, °F	878	897	899	905	908	874	905	876	904	905	884	902
Severity Factor	0.12	0.33	0.96	1.07	1.01	0.089	0.80	0.10	0.96	1.02	0.08	1.04
Conversion (400° F.+), Volume Percent	29.7	40.6	47.4	54.7	55.2	31.0	53.7	23.4	47.6	50.6	30.3	52.0
Yields:												
Carbon, Weight Percent	3.0	5.0	7.7	10.3	9.3	1.8	7.0	2.2	9.0	8.0	1.9	6.2
Gas, Weight Percent	4.1	6.4	9.4	9.9	7.9	4.3	10.2	2.7	6.7	9.2	4.4	10.7
C_4's+ Gasoline, Volume Percent	28.6	36.4	40.8	48.7	49.3	31.2	47.3	24.0	39.6	39.2	31.0	45.7
Cycle Oil, Volume Percent	70.3	59.4	52.6	45.3	44.8	69.0	46.3	76.6	52.4	49.4	69.7	48.0
Gas Molecular Weight	17.0	14.1	17.7	15.7	15.2	17.1	18.3	13.8	15.4	16.9	19.5	19.3

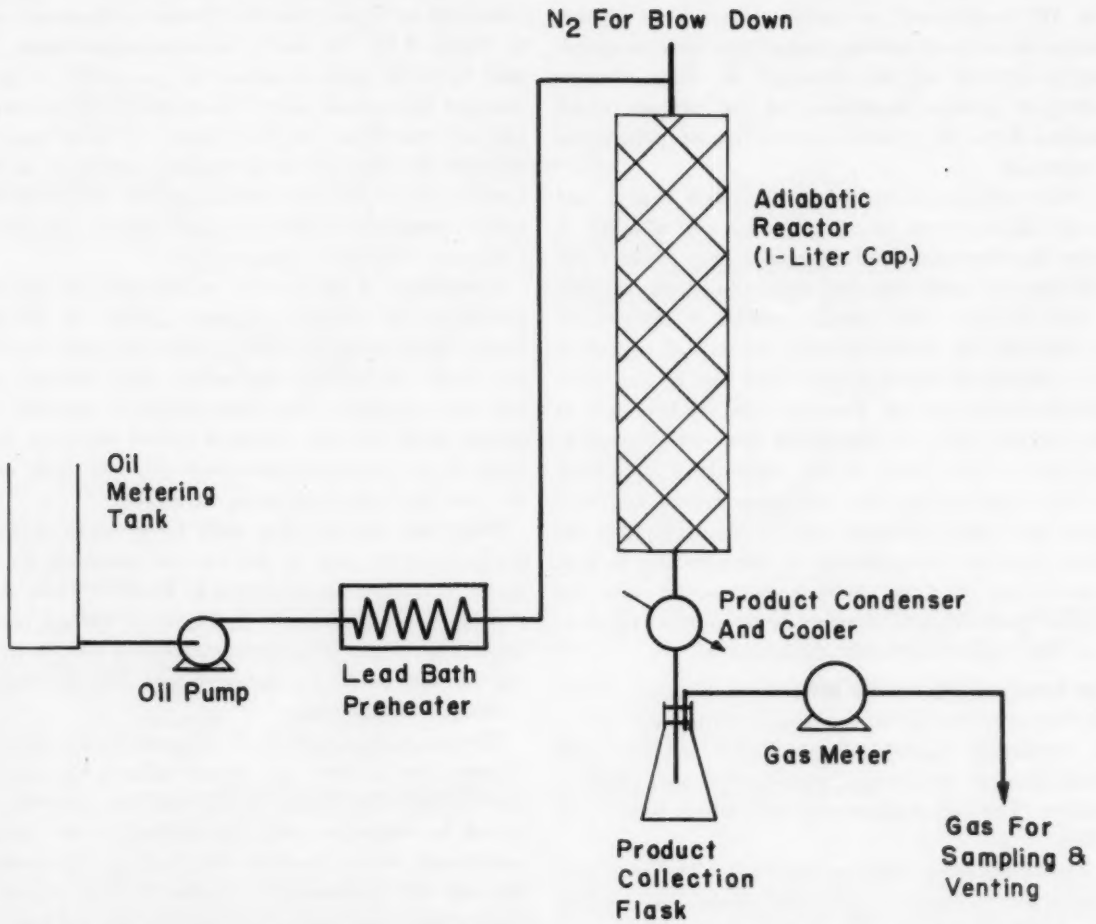

FIGURE 2—Catalytic cracking tests were carried out in a reactor of one-liter capacity, containing 3/16-inch pellets.

than with any other feed, higher gas production, and a carbon yield 3 times that of the raffinate, thus demonstrating the desirability of removing such material from the virgin feed; furthermore, four times as much severity was required to achieve 50 conversion.

On the supposition that in many installations operation would be limited by coke-burning capacity, results have been compared (Table 7) at a carbon yield of 6 percent. Under these circumstances, phenol-treated oils may be cracked at conversions 8-9 numbers greater than those permissible with unextracted oil. At the same time, dry gas yields amounted to 2-3 percent more and gasoline yields 7-10 percent more on feed with extracted oil than with unextracted oil.

As might be expected, phenol extract would have to be cracked about 21 conversion numbers below the corresponding raffinate in order to make only 6 percent

TABLE 5—Cracking Tests of Phenol Extract and Mid-Continent Gas Oil

Feed Identity	Extract From D		Mid-Continent Gas Oil			
Feed Inspections:						
Gravity, °API	9.9		34.4			
Conradson Carbon, Wt. %	12.5		0.02			
Aniline Point, °F	....		17.2			
Metals, ppm:						
Nickel	24.4		.....			
Vanadium	6.5		.....			
Experiment No.	13	14	15	16	17	18
Operating Conditions:						
Average Catalyst Temp., °F	907	902	898	911	909	905
Severity Factor	0.17	1.48	0.26	0.26	1.87	2.14
Conversion (400° F. +), Vol.%	24.8	43.1	33.7	38.0	50.4	52.4
Yields:						
Carbon, Wt. %	5.3	9.7	1.7	1.6	4.8	4.9
Gas, Wt. %	4.5	8.2	5.2	7.7	11.1	9.1
C4's + Gasoline, Vol. %	21.7	34.1	32.2	34.7	42.2	45.1
Cycle Oil, Vol. %	75.2	56.9	66.3	62.0	49.6	47.6
Gas Molecular Weight	17.7	21.5	22.2	22.9	21.6	22.2

TABLE 6—Comparison of Results At 50 Percent Conversion

	Severity Factor	Carbon Wt. %	Dry Gas Wt. %	Gasoline Vol. %
Arabian Crude:				
Decarbonizing	0.85	8.4	8.9	42.8
Decarbonizing + Phenol (Raffinate)	0.64	5.4	8.9	44.9
South American Crude:				
Decarbonizing	1.35	8.7	8.7	41.5
Decarbonizing + Phenol (Raffinate)	0.75	5.5	8.7	44.5
Decarbonizing + Phenol (Extract)	3.0	16.5	11.4	38.4
Mid-Continent Gas Oil	1.6	3.9	10.0	43.2

carbon and would produce about 18 percent less gasoline and about half as much dry gas. By comparison, gas oil could be run at about 6 numbers higher conversion than extracted oil and would produce about 2 percent more gasoline under these circumstances; the required severity factor, however, would be about 4-5 times that of raffinate.

Examination of Table 4 also shows that phenol-extracted stocks produced a dry gas of higher molecular weight than decarbonized feed by yielding more propane and propylene. The yields of butanes are unknown since the butanes in the liquid product were not measured but (with those in the gas) were included in the gasoline. Gasoline quality is also unknown as no octanes were run.

The cracking product distributions from the two reduced crude sources were similar as shown in Tables 6 and 7. Severity factors for phenol-extracted stocks were also nearly the same for both sources, indicating that phenol extraction tends to minimize differences in feedstocks when compared with decarbonizing alone.

Solvent Extraction Is Worthwhile. The primary purpose of this study was to determine whether the use of phenol extraction would permit deeper decarbonizing and thus reduce the yield of low-value fuel oil. The present experiments were carried out to study the effectiveness of phenol extraction in improving the quality of catalytic cracking feedstocks. In order to magnify this improvement, extraction was carried out under rather severe treating conditions such that the yield of raffinate was only about 50 percent on a charge basis.

In practice, an extract yield of 50 percent (solvent ratio 2.5) would require circulation of a very large amount of solvent and would thus be expensive. Interest would more probably center on a process in which perhaps only 10 percent of the cracking stock was rejected as a very aromatic extract and in which the raffinate would differ from the feed by a smaller amount than in the present tests; such operation would require a solvent ratio of only about 1.0.

Extraction studies in this and other laboratories have shown removal of the first portion of extract changes the raffinate properties by a greater amount than removal of any subsequent portion of the same size. In lube oil extraction, for example, removal of 10 percent extract has been found to give 40-50 percent as much

TABLE 7—Comparison of Results At 6 Percent Carbon Yield

	Severity Factor	Conversion, Vol. %	Dry Gas Wt. %	Gasoline Vol. %
Arabian Crude:				
Decarbonizing	0.45	44	7.0	38.5
Decarbonizing + Phenol (Raffinate)	0.80	52	9.6	46.0
South American Crude:				
Decarbonizing	0.62	43	6.6	36.5
Decarbonizing + Phenol (Raffinate)	0.94	52	9.5	45.9
Decarbonizing + Phenol (Extract)	0.36	31	5.8	27.7
Mid-Continent Gas Oil	(4)	(58)	(14)	(48.4)

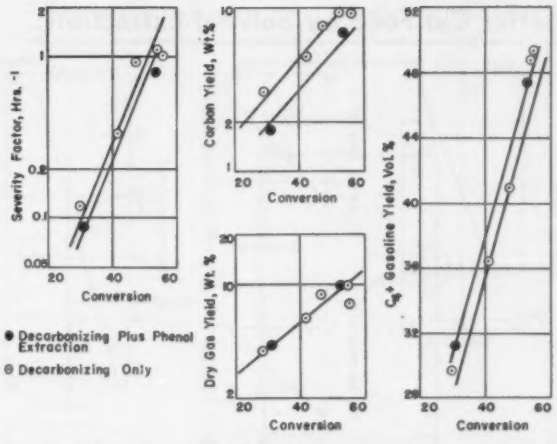

FIGURE 3—These data for the Arabian crude source show the phenol raffinate (close circles) produces a superior cracking stock compared to the unextracted charge (open circles).

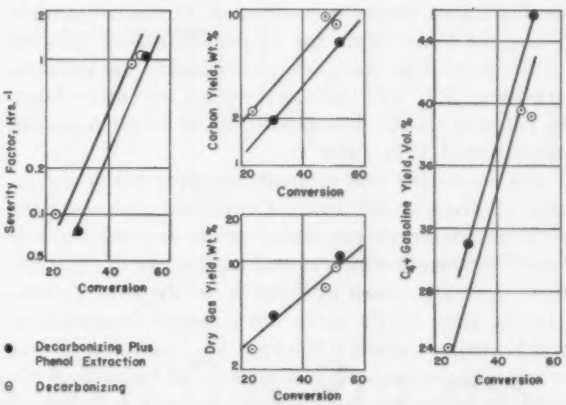

FIGURE 4—These data for the South American crude source confirm the value of phenol raffinate.

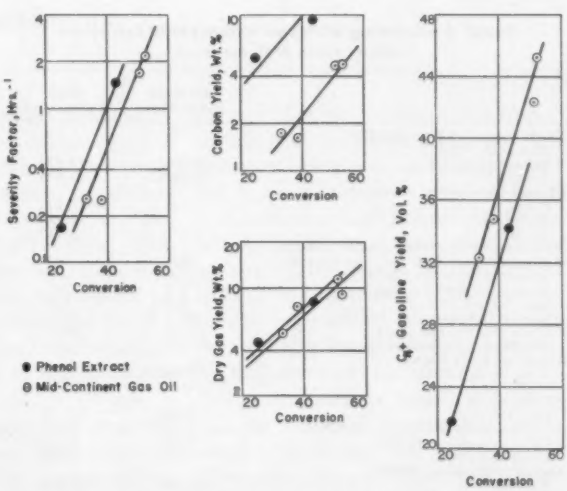

FIGURE 5—Compared here with a Mid-Continent Gas Oil, the extract from phenol extraction have none of the advantages of the phenol raffinate.

Better Cat Feed by Solvent Extraction . . .

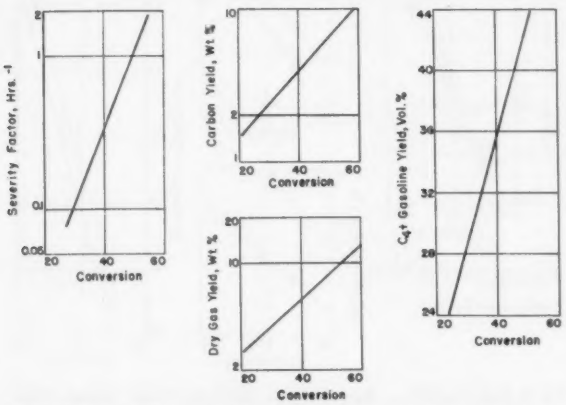

FIGURE 6—These cracking results were estimated for ten percent extract removal from the South American crude source.

quality improvement as removal of 50 percent extract. Using the lower figure for 10 percent extract removal in the present instance, we can estimate the raffinate gravity as 22.3° API and can construct the curves shown in Figure 6 for the decarbonized oil of South American origin (Stock D in Table 1).

For a cracking unit presently handling the decarbonized oil from 40,000 bpsd of residuum and operating without extraction, installation of an extraction unit would produce the incremental amounts of dry gas and C_4 + gasoline shown in Table 8 for the same carbon-burning rate. At the same time, deeper decarbonizing would result in nearly 6,000 bpsd less heavy fuel oil and would reduce the shortage of furnace oil by nearly 4,000 bpsd. Assuming gasoline, furnace oil, and heavy fuel oil are worth \$6, \$3, and \$2 per barrel, respectively, and dry gas is worth 30¢/1,000 scf, this means extraction would produce an increased revenue of \$11,898 per stream day; this figure would be even larger if allowance were made for the lower metals content of raffinate and the resulting lower catalyst replacement cost and/or higher allowable conversion.

An extraction unit capable of treating 18,400 bpsd of feed at 1:1 solvent-to-oil ratio might be expected to require an investment of perhaps three million dollars and to involve a daily operating expense of about \$2,000. Thus a net daily credit (with 90 percent stream efficiency) of approximately \$4,330 would remain after taxes, or \$1.56 million yer pear, without having made allowance for depreciation. While the above figures are admittedly shaky in view of the rather gross assumptions made, they suggest that phenol extraction of virgin cracking stock can—after taxes—pay for the required investment in about two years. Furthermore, it is possible that these economics would be even more attractive with different treating conditions (in the decarbonizer, the phenol extractor, or both) or if phenol extraction (1) were limited to the "dirtiest" part of the feed and (2) were installed as incremental capacity in connection with construction of a treating unit for handling cycle oil.

(Original presentation was before the American Institute of Chemical Engineers, San Francisco, December 6-9, 1959.)

TABLE 8—Cracking With and Without Mild Extraction
(Basis: 40,000 BPSD Residuum)

	Without Extraction	With Extraction
Decarbonizer Flows, BPSD		
Residuum Feed	40,000	
Decarbonized Oil	10,640	18,400
Asphalt	29,360	21,600
Phenol Extraction Flows		
Feed	.....	18,400
Raffinate	.....	16,560
Extract	.....	1,840
Yields from Cracking (Basis Charge)		
Conversion (400° F +), Vol. Percent	43.0	40.0
Required Severity Factor	0.62	0.33
Carbon, Weight Percent	6.0	3.9
Gas, Weight Percent	6.6	5.9
C4's + Gasoline, Vol. Percent	36.5	35.5
Cycle Oil, Volume Percent	57.0	60.0
Gas Molecular Weight (Approx.)	15	19
Cracking Unit Flows		
Feed Rate, BPSD	10,640	16,560
Lb./Hr.	145,000	222,000
Carbon, Lb./Hr.	8700	
Gas, Lb./Hr.	9,560	13,100
Thousands of Std. Cu. Ft./Day	5,800	6,260
C4's + Gasoline, BPSD	3,880	5,880
Cycle Oil, BPSD	6,070	9,930
Asphalt Blending (BPSD)		
Asphalt	29,360	21,600
Cycle Oil as Cutter Stock	23,920	23,900
Extract	.....	1,840
Total (Heavy Fuel Oil)	53,280	47,340
Excess Cycle Oil (Furnace Oil)	—17,850	—13,970

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Atteridg

Cox

About the Authors

Paul T. Atteridg is manager of the Refinery Plans Division of The M. W. Kellogg Co., New York, where he is responsible for preliminary economic evaluation of proposed refinery and petrochemical installations and for establishing an optimum process sequence for multi-process projects. Having received a Bachelor of Chemical Engineering degree from Cornell University, Atteridg was in the Research and Development Laboratory of The M. W. Kellogg Co., Jersey City for 12 years. Before assuming his present duties, he was Section head in charge of process development.

Robert P. Cox is a technical specialist with the Aerojet-General Corp., Sacramento, Calif. At the time he gathered material for the accompanying article, he was a research chemical engineer for The M. W. Kellogg Co., Jersey City, where he did process development studies on refinery and petrochemical processing. Having received a B.S. degree in chemical engineering in 1950 from Virginia Polytechnic Institute, Dr. Cox moved to Iowa State University to receive M.S. and Ph.D. degrees in chemical engineering.

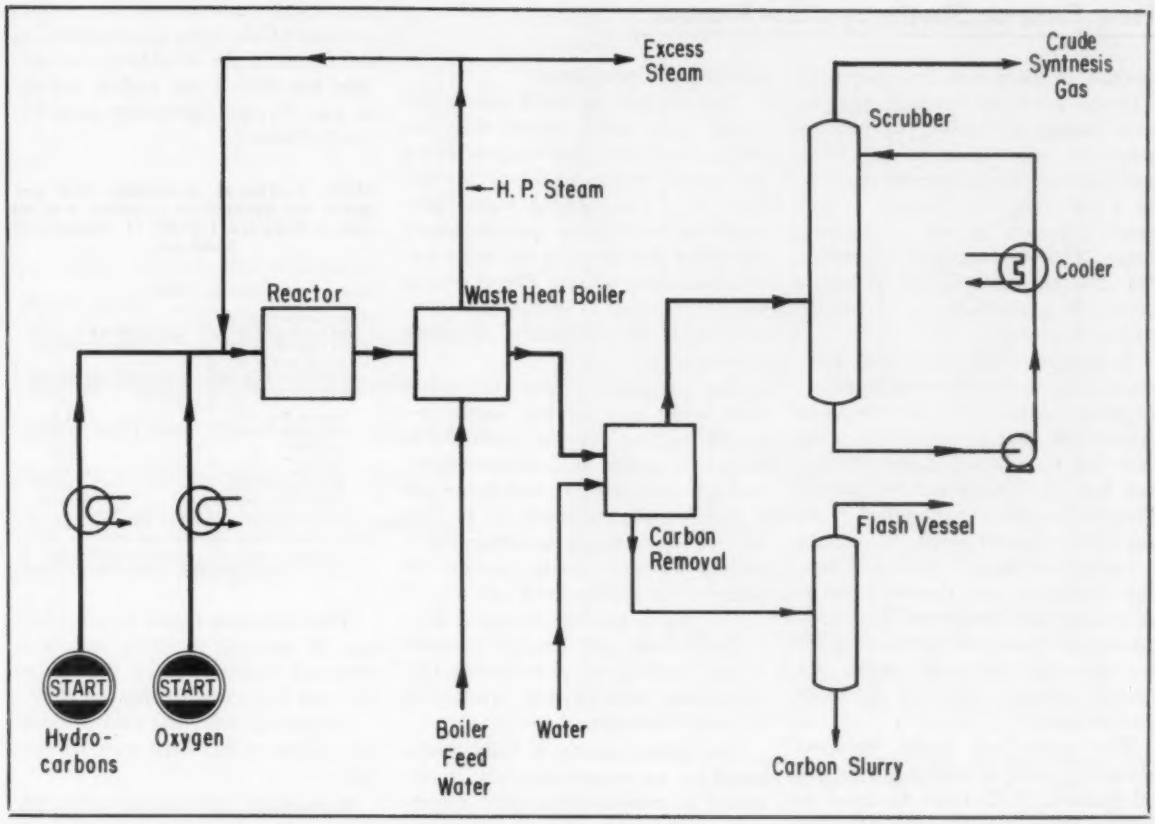

FIGURE 1—Shows the unique features of waste heat boiler in Shell's gasification unit for synthesis gas production.

New Data on Shell's Syn Gas Process

Here are the first commercial data from Shell's new oil gasification process for synthesis gas production

A. P. van Amstel
Mekog, Ijmuiden, Holland

THE SHELL OIL gasification process has been a commercial success since 1956. Results from the first prototype commercial plant have been reported elsewhere.[1] Operation of the plant at the Mekog works has given extremely satisfactory results as regards on-stream time, maintenance, ease of operation and yields. The process has proved to be a reliable component of the Mekog synthesis gas train. Experience has been such that the Mekog Company has decided to erect a second Shell gasification plant.

The Shell gasification process is based on the partial oxidation of a hydrocarbon feedstock in the presence of steam by oxygen, by air enriched with oxygen or by air, depending on the application. The reaction is a continuous, non-catalytic flame type which takes place in a reactor specially developed for the purpose. The reaction conditions can be readily adapted to the feedstock selected.

The process is capable of converting any hydrocarbons, from methane through light gasoline to residual oil. The main products of the reaction are carbon monoxide and hydrogen, together with minor quantities of carbon dioxide, methane, hydrogen sulfide and carbonylsulfide, the last products being formed from the sulfur in the feedstock.

A certain quantity of carbon (from a few tenths to a few percent by weight on feedstock) is also formed during the reaction. This amount can be kept within acceptable limits by a suitable choice of the oxygen-to-oil and steam-to-oil ratios.

The pressure at which the plant can be designed to operate ranges from 5 to 40 atm and even higher, if required. Apart from the flexibility which this offers, it will be clear that the possibility of working at high pressure enables a considerable re-

duction in the size of the equipment. The compact construction that results makes it feasible to produce relatively large quantities of water gas in small plants, thereby reducing to a minimum the amount of plot space required, as well as the heat losses. This high-pressure operation has also resulted in an attractive saving in compression costs for the Mekog Company.

A feature of oil gasification processes is the high reaction temperature (approx. 1,200-1,500° C). It will be appreciated that a considerable economy can be effected if the exothermic heat of reaction can be utilized. Despite the presence of carbon in the gas it has been possible to develop a waste heat boiler which can produce steam of any desired pressure in continuous operation. The steam produced is used for preheating the reactants and for injection into the reactor together with the feedstock and oxygen.

The waste heat boiler produces about 2.3 tons of steam per ton of oil gasified. 0.75 tons is used as process steam and for preheating oil and oxygen, leaving an excess of 1.55 tons, which is piped to the general steam system.

The carbon formed during the reaction is removed from the gas by a water wash, resulting in a concentrated carbon/water slurry (10—15 g/1).

The Mekog gasification plant was designed to convert 50 metric tons of fuel oil a day into water gas at a pressure of some 25 atm.

The oxygen, which comes from an air separation unit, is compressed by reciprocating compressors to about 30 atm. The preheating to about 220° C then takes place in coil-in-coil heaters with steam. The oxygen is then mixed with the steam required for the process and introduced into the reactor.

The fuel oil is pumped to a coil-in-coil preheater, in which it is likewise steam-heated to approx. 220° C before introduction into the reactor. The fuel oil, oxygen and process steam are intimately mixed in a combustor of special Shell-patented design before entering the reaction zone.

The reactor is lined with refractories backed by insulating material to minimize heat losses.

The reaction products pass to the waste heat boiler, where they are cooled down to a few degrees above the steam temperature (approx. 230° C). The Mekog waste heat boiler incorporates a special feature obviating the necessity for boiler circulation water pumps. This of course means a saving in energy and contributes to the reliability of plant operation.

The gas coming from the waste heat boiler goes to the carbon removal section. Before leaving this section it passes as a double check through a scrubber in which the gas is further cooled to about 30° C. The carbon/water slurry is subsequently flashed to atmospheric pressure in order to release dissolved gas.

The gas is further processed in a COS-removal unit and hydrogen sulfide wash before it enters the CO conversion unit for the production of crude hydrogen.

The plant, which is fully monitored by automatic controls, is operated by two men per shift. Supervision is required on a part-time basis only.

The operation of the Shell gasification plant at the Mekog works has proved to be most satisfactory from every point of view since the plant was taken over.

Feed Stocks. Hydrocarbon oils ranging in viscosity from 800 to 3,500 sec Redwood I/100° F and with sulfur contents of up to 3.5 percent by weight have been gasified without any difficulty.

Capacity. The thruput of the plant was varied in accordance with synthesis gas requirements from 35 tons up to 60 tons of fuel oil a day with no noticeable effect on the reactor or any other part of the unit or on the purity of the gas obtained. It is in fact believed that the plant intake could be increased still further, but in the absence of additional oxygen compression facilities at the Imuiden works this possibility has not yet been investigated.

Carbon. Especially satisfactory is the very low carbon content of the gas leaving the plant, which facilitates its further processing in the hydrogen sulfide removal and CO conversion installations. The carbon content of the gas, as measured at the outlet of the scrubber, is invariably less than 1 mg carbon per m^3 of gas. Typical operating data follow in Table 1.

TABLE 1—Typical operating data per metric ton gasified of a typical fuel oil with a Redwood I (100° F) viscosity of 3500 sec[1]

Oxygen consumption (as 100%) at 95% purity	approx. 750 Ncm
Steam produced in waste heat boiler (at 26 atm)	approx. 2.3 ton
Steam used in the reactor	approx. 0.4 ton
Dry water gas produced (at 30° C and 20 atm)	approx. 2950 Ncm
Average composition of water gas (in % vol on a dry basis)	
carbon dioxide	4.6
carbon monoxide	47.0
hydrogen	46.0
methane	0.2
nitrogen + argon	1.4
hydrogen sulfide	0.8
carbonyl sulfide as S	200–300 ppm
carbon content less than 1 mg/Ncm.	

[1] Analysis feedstock, weight per cent 84.6% C; 11.3% H, 3.5% S, 0.13% O, 0.4% N, 0.07% ash.

The on-stream factor for the plant was 92 percent in 1958, and it is expected that it will be possible to increase this even further in 1959.

Experience with the various items of equipment has been very favourable.

Refractory. The special refractory chosen for the reactor lining has performed extremely well and no replacement has been necessary since it was installed in 1956. The same refractory lining will probably last for several years to come. The vanadium oxide that could originate from any vanadium compounds present in the feed stock will not attack the refractory material under the reducing conditions prevailing in the reactor.

Boiler. The waste heat boiler has required no cleaning or maintenance, since the start-up. Steam production remained constant. The design did not provide for any carbon removal facilities, and operation has in fact proved that no carbon is deposited in the boiler.

Corrosion. The entire gasification plant, except for the oxygen feed system, is constructed of carbon steel. Corrosion, however, was found to be negligible. Inspection of the unit after 18 months of operation showed that the wall thickness in different parts of the units was practically unchanged.

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The relative road performance of motor fuels can be determined now without resorting to expensive test car techniques. Try these equations which use conventional laboratory analyses

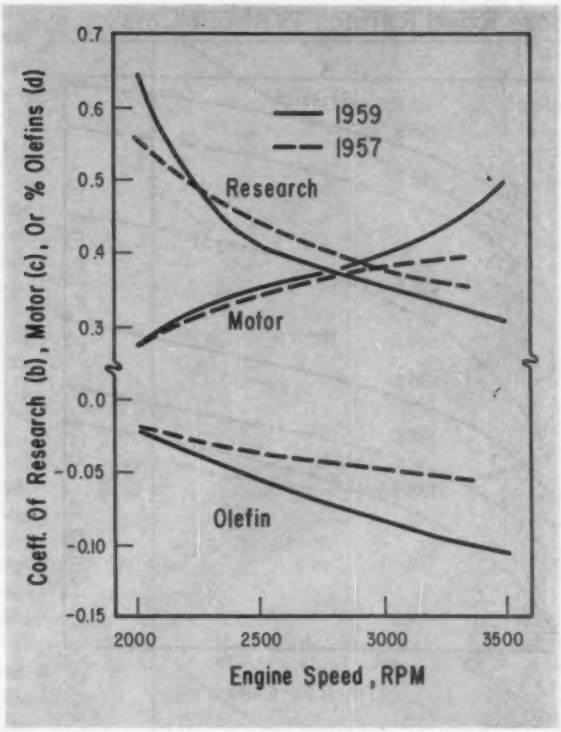

FIGURE 1—For five makes of vehicles, here are the average values of the coefficients in the equation: $Y = a + bR + cM + dO$.

Now Explore Road Ratings Without Test Cars

George H. Unzelman
Ethyl Corporation, New York City

F. D. Buerstetta
Ethyl Corporation, Detroit

THE ROAD RATING of a motor fuel is the final judge of a fuel's octane quality. The road rating, however, can be estimated now from laboratory analysis so that the relative performance of fuels can be compared without resorting to expensive test car techniques.

The estimation method is based on a correlation between the road performance of a gasoline and its laboratory octane ratings plus a chemical analysis. The method was suggested by Ethyl Corporation in 1957 after a statistical review of data from a large number of premium gasolines. Then the statistical review was repeated in 1959 to see how the relationship might have changed for more modern cars.

In equation form the relationship is expressed as follows:

$$y = a + bR + cM + d\,(O \text{ or } A)$$

where y = Road octane number
R = Research octane number
M = Motor octane number
O = Olefins, vol %
A = Aromatics, vol %

The constants a, b, c, and d are established for each test car at various ratings speeds. An example of the values for these constants is shown in Figure 1. Their source and significance will be discussed later.

The conclusions reached from the more recent statistical study are as follows:

- Laboratory octane numbers may be used to provide estimates of road antiknock performance in 1959 cars. Whether Research or Motor octane

Explore Road Ratings Without Cars . . .

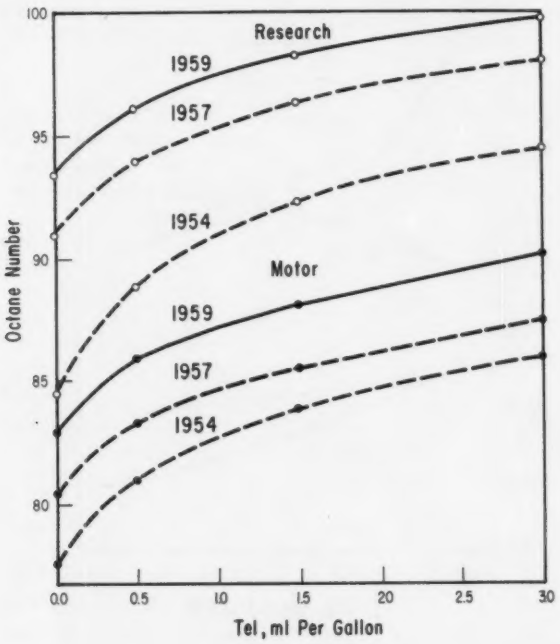

FIGURE 2—Motor octanes have increased at a greater rate than Research octanes during the period between 1957 and 1959.

number is more important varies with the car, engine speed and throttle setting.

- A fuel property such as hydrocarbon composition and either Research or Motor octane also is a good index of road performance.
- Low speed road performance in 1959 cars at full throttle operation depends primarily on Research octane number. For high speed, Motor octane is more important.
- Experimental high compression cars were more appreciative of Research octane numbers than the 1959 cars.
- Part-throttle road behavior is controlled almost entirely by Motor octane. An increase of sensitivity is generally detrimental.
- Where Research octane is the same, fuels with maximum paraffin hydrocarbons give optimum road performance.
- Where Research octane and sensitivity are the same, fuels with more aromatics and less olefins show better road performance at high speeds.

Based Upon Fuels From Entire Industry. The 1957 statistical analysis which led to the development of the road performance correlation was based upon commercial premium fuels submitted from 83 refineries which produced 75 percent of the motor fuel in the United States.

The recently completed 1959 study of currently-marketed, commercial premium gasolines re-evaluates the empirical correlation between road antiknock behavior and laboratory characteristics. One hundred thirty-one motor gasolines—112 premium and 19 super premium fuels were thoroughly tested in the laboratory and on the road. In all, almost 20,000 octane number determinations were made during the study. Tables 1A and 1B typify information derived for each fuel. Road tests were made in five 1959 test cars and three additional test cars equipped with experimental high compression engines using both Modified Uniontown and Modified Borderline procedures. All fuels were blended to contain 3 ml TEL/gal to eliminate TEL as a variable.

Because of the increase of part-throttle knocking

TABLE 1A—Typical Laboratory Inspection Data

HYDROCARBON TYPE, VOLUME PERCENT		TEL SUSCEPTIBILITY			ASTM DISTILLATION, °F	
Aromatic	26	Research @	0.29 ml TEL	96.8	IBP	83
Olefin	31	Research @	0.5	97.2	5 Percent Evap.	93
Saturate	43	Research @	1.5	98.7	10	107
Gravity, °API	60.6	Research @	3.0	100.1	15	120
Vapor Pressure, psi	11.6	Research @	4.0	100.9	20	130
ASTM Gum, mg/100 ml	0.6	Motor @	0.29 ml TEL	84.2	50	212
Sulfur, Weight Percent	0.025	Motor @	0.5	84.9	90	335
Bromine Number	59	Motor @	1.5	86.8	95	360
		Motor @	3.0	89.1	EP	407
		Motor @	4.0	90.4		

TABLE 1B—Road Antiknock Data

(@ 3.00 ml TEL, 100.1 Research ON, 89.0 Motor ON, 11.1 Sensitivity)

CAR IDENTITY	MODIFIED UNIONTOWN		MODIFIED BORDERLINE @ RPM SHOWN					
	Rating	RPM[1]	1650	2000	2500	3000	3500	4000
1959 A	98.9	2100	.....	99.0[5]	98.3	96.8	95.2	93.6
1959 B	101.0	2750	102.5[3]	99.8	98.5	97.4	95.9	....
1959 C	98.3	2900	.....	99.5[5]	99.0	97.3	94.1	....
1959 D	97.9	1850	98.4[4]	97.9	97.4	96.5	94.8[6]	....
1959 E	98.8	3200	100.4[2]	99.9[2]	99.4	97.8	96.2	92.9
12:1 C.R. Car AA	99.8	2750	.....	99.6	99.6	98.3	97.8	....
12:1 C.R. Car FF	100.1	1500	99.0	100.6	101.0	100.4	98.7	....
11:1 C.R. Car GG	99.4	2750	.....	99.9[6]	99.4	98.0	95.0	....

[1] Engine speed at trace knock. [2] 1200 rpm, [3] 1,700 rpm, [4] 1,850 rpm, [5] 2,100 rpm, [6] 3,200 rpm.

complaints in recent years, a special study of this problem was made with 30 select "pilot fuels." Part-throttle octane requirements at manifold vacuums ranging from 8 to 15 in. Hg. were investigated for the five 1959 cars. Table 2 shows the range of fuels studied.

Motor Fuel Trends Since 1957. Some of the average properties of fuels used in the 1957 and 1959 studies are compared in Table 3. These data reflect the recent trend in premium gasolines toward higher Research and Motor octane numbers, higher aromatic content, and lower olefin content. A better concept of octane trends may be had by an examination of Figure 2 which includes average 1954 TEL susceptibility. Since Motor octane has increased at a greater rate than Research, the average sensitivity (RON minus MON) is lower for the 1959 group of fuels. This reverses the historical trend to increasing sensitivity as higher Research octane levels are reached. A detailed study of fuel compositions show that the increase in Research and Motor octane numbers for super-premium gasoline was accomplished in most cases by substituting alkylate for light cracked gasoline. Thus, the average paraffin and iso-paraffin content is higher while the olefin content is lower. In the case of premium fuels, the trend has been to more aromatics and less olefins. This has been brought about by the inclusion of higher percentages or more severely reformed components. At the same time, cracked fractions have probably been shifted to regular grades.

TO DEVISE THE CORRELATION FOR PREDICTING ROAD PERFORMANCE

A critical study of various forms of empirical correlations between road octane number and laboratory inspection data have substantiated that the best predictions of road performance can be made from three basic laboratory qualities: Research and Motor octane numbers and hydrocarbon composition. The substitution or inclusion in the equation of fuel properties such as API gravity, sulfur content, TEL susceptibility does not greatly improve prediction accuracy. Nor, are higher order terms such as squares and products of Research and Motor numbers of any added significance.

Simpler forms of the equation were also tested. For example, correlations were obtained based upon: Research octane alone, Motor octane alone, Research and Motor octanes combined, and combinations of either Research octane or Motor octane with a term for hydrocarbon type. This work confirmed the following previous findings:

- Research octane number is a fairly good predictor of low-speed road octane number, but decreases in significance as engine speed increases.
- Motor octane number has little effect on prediction of low-speed road octane number, but increases in significance as engine speed increases.
- Percent olefins (or percent aromatics) has very little effect on prediction of low-speed road octane number but increases in importance as engine speed increases.

Accuracy of the most promising correlation equations is shown in Table 4. It is obvious that both the constant (a) and the hydrocarbon factor contribute sig-

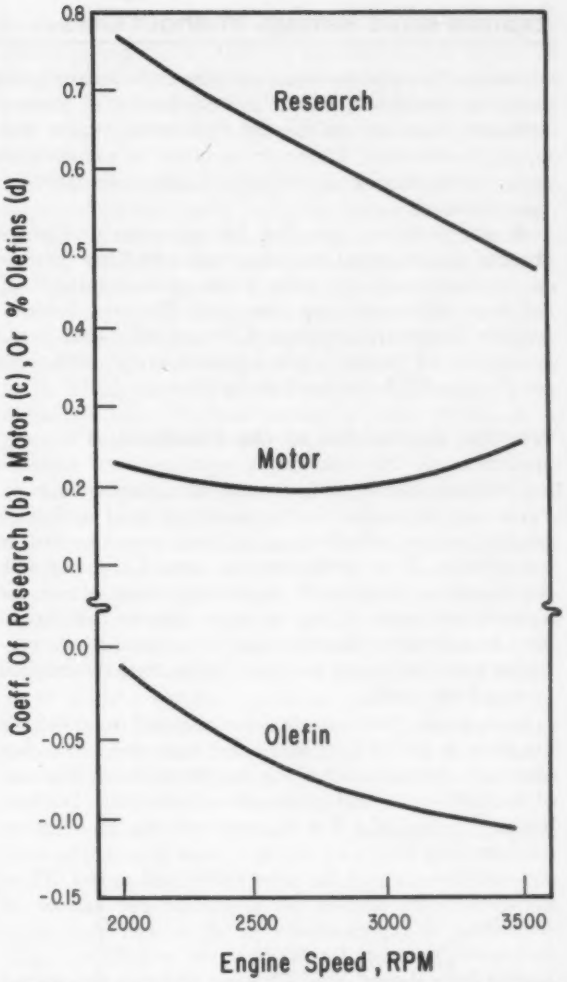

FIGURE 3—These are the average values of equation coefficients for two experimental vehicles having 12:1 compression ratios.

TABLE 2—Range of 30 Pilot Fuels Used in Study of Part-Throttle Knock

RATINGS	Average	High	Low
Research ON	100.2	103.7	95.8
Motor ON	90.3	96.5	87.2
Sensitivity	9.9	11.7	7.2
Percent Olefins	19	37	5
Percent Aromatics	29	45	5

TABLE 3—Average Fuel Properties

RATINGS	PREMIUM		SUPER-PREMIUMS	
	1957 (91 Fuels)	1959 (112 Fuels)	1957 (12 Fuels)	1959 (19 Fuels)
Research ON @ 3.0 ml TEL	98.1	99.7	100.8	102.7
Motor ON @ 3.0 ml TEL	87.6	90.2	90.0	93.1
Sensitivity	10.5	9.5	10.8	9.6
TEL Susceptibility (0.0 to 3.0 ml TEL)				
Research ON	7.0	6.2	6.3	5.8
Motor ON	7.2	7.2	7.1	7.0
Hydrocarbon Type, Vol %				
Aromatic	24	29	30	29
Olefin	24	18	18	15
Saturate	52	53	52	56

nificantly to equation accuracy when the entire speed range is considered. Either percent olefins or percent aromatics may be used as the hydrocarbon term with equal effectiveness. However, in order to remain consistent with previous investigations, the olefin term has been retained.

It will be shown later that for low-speed predictions the olefin term could be eliminated with little increase of standard error. The same is true of the constant (a) for some high speed car situations. However, for uniformity, the general equation $Y = a + bR + cM + dO$ is used for all speeds. Table 5 gives average coefficients for the five 1959 cars used in the study.

Practical Application of the Equations. The main application of the road rating equation is to compare the individual road performances of a number of fuels. Fuels may be ranked in the order of road antiknock quality just as effectively as if they were checked in test vehicles. If the coefficients in Table 5 are used with the equation to calculate an average road octane for a single fuel, then this is the same number that would have been obtained had the fuel been rated in the particular cars and results averaged at the time the original ratings were made.

In appraising the worth of calculated road octane numbers, it should be remembered that even the values obtained experimentally for a fuel by different test cars of the same make and model can differ widely. Further, the road octane of a fuel obtained with the *same* car on different days may vary but to a lesser degree than with *different* test cars of the same make and model. Thus, the coefficients derived for a specific car cannot be considered as representative of all cars of that make and model, nor even for the same car at different times. Studies have shown, however, that "relative ratings" of individual fuels in a group are consistent and fuels may be ranked in the order of road antiknock quality just as effectively by use of the prediction equation as with test vehicles.

TABLE 4—Accuracy of Various Correlation Equations
(Based on 131 Fuels)

	Standard Error, ON
Road ON = b(Research ON) + c(Motor ON)	0.96
Road ON = a + b (Research ON) + c(Motor ON)	0.93
Road ON = b(Research ON) + c(Motor ON) + d(% Olefins)	0.84
Road ON = a + b (Research ON) + c(Motor ON) + e(% Aromatics)	0.76
Road ON = a + b (Research ON) + c(Motor ON) + d(% Olefins)	0.77

TABLE 5—Average Coefficients in Equation Relating Road Octane Number to Laboratory Variables—Full Throttle
Road ON = a + b (Research ON) + c (Motor ON) + d (% Olefins or Aromatics)

Five 1959-Car Average	a	b	c	d	Standard Error, ON
Modified Uniontown	28.90	0.419	0.325	—0.038	0.74
Modified Borderline					
2000 rpm	11.48	0.644	0.273	—0.027	0.67
2500 rpm	26.84	0.408	0.359	—0.054	0.65
3000 rpm	27.50	0.371	0.386	—0.083	0.71
3500 rpm	21.99	0.313	0.502	—0.107	0.96

EQUATION COEFFICIENTS CAN EXPLAIN FUEL FACTOR EFFECTS ON ROAD OCTANE

With any commercial gasoline, there is a degree of correlation between the laboratory qualities that have been used in the prediction equation. For example, as Motor octane is increased, Research octane generally is also increased. Likewise, there is a correlation between olefin content and Motor or Research octane number. Because of this intercorrelation, coefficients (b, c, and d) do not, by themselves, show the exact effect on road octane number of Research, Motor, and olefin content respectively. However, this variation is probably not large and some interesting comparisons can be made to explain fuel factor effects. It is likely that the variation is cancelled when coefficients for the rating equation from one test car group are compared with those derived from another test car group—assuming, of course, there is general similarity of fuels.

Five 1959 Cars Compared with Five 1957 Cars. Figure 1 graphically shows the average values of the equation coefficients for the five 1959 test vehicles. Research octane is of primary importance during low speed operation and its effect decreases as engine speed increases. Motor octane is far less important at low speeds but becomes more important than Research above 2,800 rpm for the five car average as shown by the larger equation coefficient.

Similar average equation coefficients for five 1957 test vehicles developed during the 1957 study of antiknock behavior of premium motor fuels are shown as dashed lines in Figure 1. Cars were the same make as those used in the 1959 program. The comparison indicates the effect of Research octane in 1959 increased at low speeds from that of 1957. At the same time, Motor octane became of greater importance at high speeds.

The impact that hydrocarbon composition has upon road performance in 1959 varies greatly with engine speed. The olefin coefficient is small at 2,000 rpm but is increased threefold at 3,000 rpm. Since the olefin coefficient is negative, there is a depreciating effect upon road octane as olefin content is increased. For example, at 3,000 rpm at the same Research and Motor level, 10 percent more olefins means 0.8 less road octane.

The slope of the olefin coefficient curve has increased sharply since 1957, and for the 1959 cars at high speeds the olefin coefficient has doubled. Thus, the depreciating effect of this type of fuel component is considerably greater in the current average premium fuel car.

What Experimental Cars Show. Average values of equation coefficients for two 12:1 compression ratio experimental vehicles are shown in Figure 3. The depreciating effect of the olefins is about the same as with current vehicles but Research coefficients indicate the high compression cars are more appreciative of Research octane number. At the same time, Motor octane number has less influence on road performance in the experimental vehicles. This is true across the entire speed range.

Effect of Boiling Range of Hydrocarbons. The effect of the boiling range of hydrocarbons with a particular fuel may be significant with some cars. While the effect

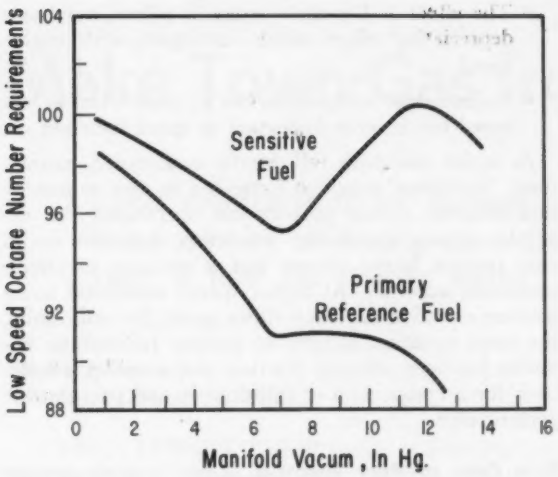

FIGURE 4—The spark advance curve is usually a compromise to give the best economy without part-throttle knock limiting on a typical commercial fuel. A typical part-throttle-limited vehicle might have the octane requirement shown here.

of component boiling range is not specifically defined by the prediction equation, it is suggested by the sign of the olefin coefficient at low engine speed.

During the initial part of an acceleration when intake-manifold velocities are low, the heavy portion of a fuel may not completely vaporize, and may lag in the manifold as liquid fuel. Under these conditions, only the light portion of the fuel may reach the cylinders and the road rating may reflect only the antiknock quality of the light fuel components.

Fuel segregation of this type is indicated in cars where the olefin coefficient is positive at low speeds. Inspection of low-speed data for these cars reveals unusually low road ratings for some low-sensitivity fuels. Since this is contrary to what is normally expected, poor behavior of such fuels is probably a distribution problem.

For example, this can occur when high octane components are concentrated in the higher boiling fuel fractions (probably aromatics) and low octane components (probably normal paraffins) are concentrated in the front end. This suggests that the road performance of the fuel might be corrected by including high octane material (light catalytic naphtha containing olefins) in the "front end fill." Of course, a detailed study of the problem would involve fractional analysis accompanied by an octane profile study of the fuel.

THE RECENT PROBLEM OF PART-THROTTLE KNOCK

Part-throttle knocking complaints have become more prevalent for some premium-fuel-requirement passenger cars in recent years. It is not unusual in some modern high compression vehicles for part-throttle requirement to set the fuel needs of the car. As a result of keen interest on the part of refiners, the part-throttle knock problem was incorporated in 1959 premium fuel study program. Thirty representative premium fuels were tested in the same five 1959 passenger cars and data were statistically analyzed with an approach similar to the full-throttle investigation.

A definition of part-throttle knock may be helpful before giving a discussion of the fuel-engine aspect of the problem. Part-throttle knocking generally occurs at a point between full throttle and road load, usually at low engine speed and from 8 to 14 inches manifold vacuum.

When the engine designer develops a new passenger car engine, a number of compromises are made to obtain optimum performance and durability for a given cost, weight, and fuel requirement. One compromise is in the ignition advance curve. The full-throttle advance curve is usually retarded from maximum power by 1 to 2 percent in the mid-speed range. This yields optimum engine power for a given octane requirement. By taking this small initial power loss, the octane requirement is reduced sharply—2.5 to 4 octane numbers. This establishes a full-throttle requirement for the engine.

To improve fuel economy at road load and between road load and full-throttle, a vacuum advance unit is usually added to the distributor. This unit provides additional spark advance which adds to the centrifugal advance at light engine loads. The spark advance curve cannot be set for optimum economy across the entire part-throttle range without increasing requirement excessively. So a compromise curve is developed which gives the best economy without part-throttle knocking problems on a typical commercial fuel. If not enough compromise is made, the vehicle will be part-throttle knock limited. Octane number requirements for such a vehicle are shown in Figure 4.

With sensitive reference fuel, octane requirement

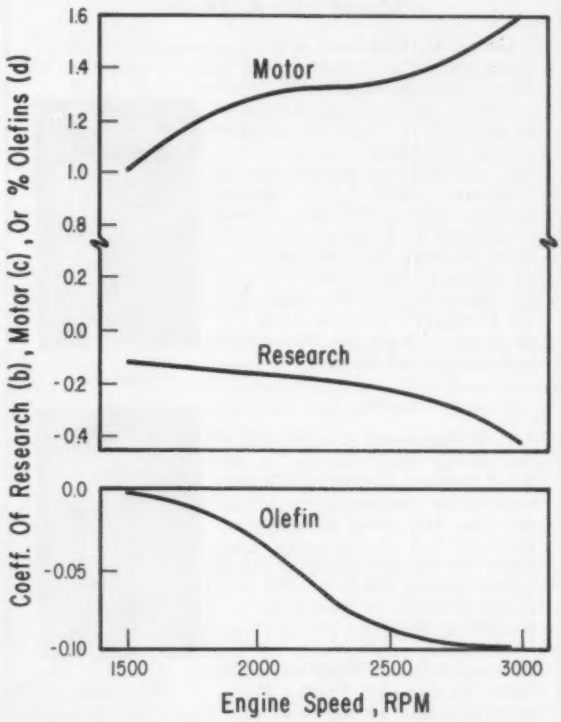

FIGURE 5—The part-throttle requirements for five 1959 vehicles show the Motor octane rating to be the most important factor.

peaks at a manifold vacuum of about 12"—and is a number higher than at full throttle. This is due to severe depreciation of sensitive fuels (those having large differences between Research and Motor octane) at light loads. Under these conditions, carburetor mixtures are leaner, mixture temperatures higher, and exhaust gas dilution is greater—all of which contribute to the depreciation of the sensitive fuel.

A Study of Part-Throttle Knock. In order to appreciate fully the fuel properties that affect part-throttle road behavior, regression equations were developed correlating part-throttle road octane number with laboratory data. As a result of the statistical review and analyses of individual car data, the following conclusions were drawn:

- Throughout the speed range, Motor octane number is the most important fuel factor.
- The effect of Research octane is minor, but has a depreciating effect which increases with engine speed.
- Hydrocarbon composition has a minor effect at low speed but is more important as speed increases.

As is the case with full-throttle road rating correlations, "cut-down" equation forms can be used to portray fuel behavior during part-throttle operations. For example, at low speeds the prediction equation would only require Motor octane and a constant to obtain maximum accuracy. At higher speeds additional terms increase equation accuracy. Once again, for uniformity, the same equation as used to portray full-throttle behavior has been adopted. Further, this provides a better basis for a comparison of full-throttle and part-throttle performance.

TABLE 6—Average Coefficients for Part Throttle

Five 1959-Car Average	a	b	c	d	Standard Error, ON
Modified Uniontown....	15.25	—0.122	0.997	—0.015	0.98
Modified Borderline					
1500 rpm.....	14.30	—0.118	1.000	—0.011	0.83
2000 rpm.....	— 9.79	—0.159	1.296	—0.027	0.96
2500 rpm.....	— 9.35	—0.211	1.343	—0.086	1.33
3000 rpm.....	—15.15	—0.414	1.615	—0.096	1.44

Five Cars at Part Throttle. Table 6 gives average equation coefficients for five 1959 vehicles which relate part-throttle road octane number to laboratory inspections. Standard deviations of ratings obtained at part throttle are considerably greater than those for ratings obtained at full throttle. Therefore, in studying part-throttle knock, Table 6 should be used to establish trends and indicate limiting conditions rather than emphasize rating differences between specific fuels. Figure 5 graphically shows the average part-throttle equation coefficients in the same style as was used in Figure 1 for full-throttle.

The conclusions stated above may be substantiated by examining Figure 5. The importance of Motor octane is indicated by the magnitude of the coefficient throughout the speed range—from 1.0 at 1,500 rpm to 1.6 at 3,000 rpm. The Research coefficient indicates little effect at low speeds and increases negatively as speed increases. This means that if the Motor octane of a fuel is held constant, an increase in the Research octane would actually reduce the part-throttle road rating. Fortunately, in most practical situations, an increase in Research octane is accompanied by an increase in Motor octane number, and, therefore, the net effect is beneficial.

The olefin coefficient is negative and indicates a depreciating effect of these components upon part-throttle road behavior. The effect increases with speed.

CONCLUSION

In the final analysis, it is the road octane number of motor fuel that governs fuel quality. Just exactly how the road performance factor is equated to specifications will vary with the refining and marketing situation.

The "test car route" is expensive and requires a number of road ratings in different cars for each fuel. The "customer complaint" system may be even more expensive. Therefore, the real value of the road performance relationships discussed above is in providing an inexpensive method to examine the relative road performance of motor fuels.

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About the Authors

George H. Unzelman is technical assistant to advertising and sales promotion for Ethyl Corporation in New York. Responsible for Ethyl's research advertising series, he is involved in various technical writing assignments and films dealing with refinery subject matter. Unzelman joined Ethyl Corporation in 1955 at Detroit and was transferred to Tulsa in 1956 as a Sales Refinery Technologist. Prior to joining Ethyl, he was associated for eight years with Continental Oil Company's Manufacturing Department at both the Ponca City and Billings refineries.

Unzelman

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F. D. Buerstetta is supervisor of the Motor Fuel Section in the Ethyl Refinery Technology Department at the Detroit Research Laboratories. His group is largely responsible for the studies upon which the accompanying article is based. Joining Ethyl in 1950 as a chemical engineer, Buerstetta has worked in Refinery Technology with primary responsibility for fuel behavior research. Prior to joining Ethyl, he was with Phillips Petroleum Company in the Crude Oil Production Department, and has authored numerous technical papers and publications.

Buerstetta

Make Town-Gas from Refinery Off-Gas

Local requirements for heating gas in England are being met by reforming gases from nearby refineries. Here is how the process works

Michael Swiss
Wembly, Middlesex, England

TO SUPPLEMENT THEIR supply of town-gas from coal, the North Thames Gas Board of England launched into a program to reform tail-gas from nearby refineries. The actual reforming is carried out at the Romford Gas Works using a nickel catalyst in a non-continuous process. For this operation, feedstock is furnished by Shell Petroleum Company's refinery at Shell Haven and Mobil Oil Company's Coryton refinery.

The conversion of refinery gases into town-gas is gaining prominence in England lately. The recent growth of refineries and the shortage of suitable coal give impetus to this trend. An example is Esso Petroleum Company's Fawley refinery which supplies gas to the Southampton Gas Works where 4 million cubic feet of town-gas are produced daily. Another unit was built by Power Gas Corporation near the British Petroleum Company's refinery at the Isle of Grain and is using gases and liquid hydrocarbons to supply 20 million cubic feet of town-gas to the South Eastern Gas Board. Likewise the North Western Gas Board, whose area includes Manchester and Liverpool, has signed a contract with Shell Petroleum Company to receive 2 million cubic feet of gas per day from the Stanlow refinery. This gas will be reformed to produce about 12 million cubic feet of town-gas daily.

The biggest of these installations is the Romford plant. Built by Humphreys and Glasgow, the plant was completed in May 1958, and started receiving regular supply of feed in August 1958. Its daily output of 36 million cubic feet is about 1½ percent of the Gas Board's total production. The plant achieves this output with only three of its four processing units in operation. When in

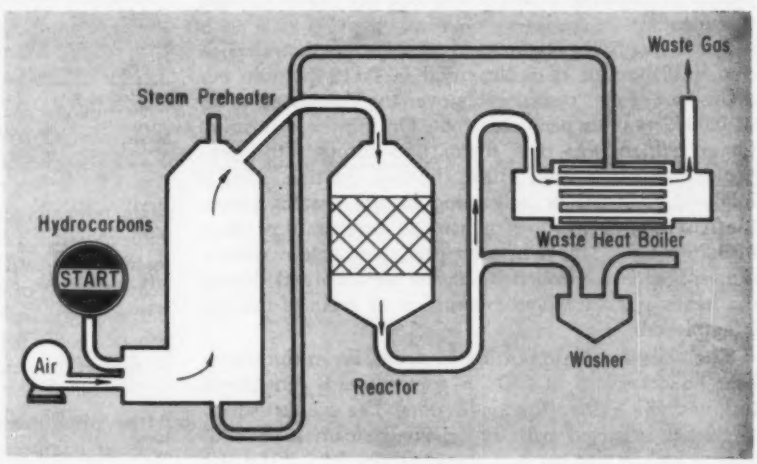


FIGURE 1—During the heating phase (above), some of the hydrocarbon is combusted with air. This heats the reactor bed and produces steam for the subsequent step.

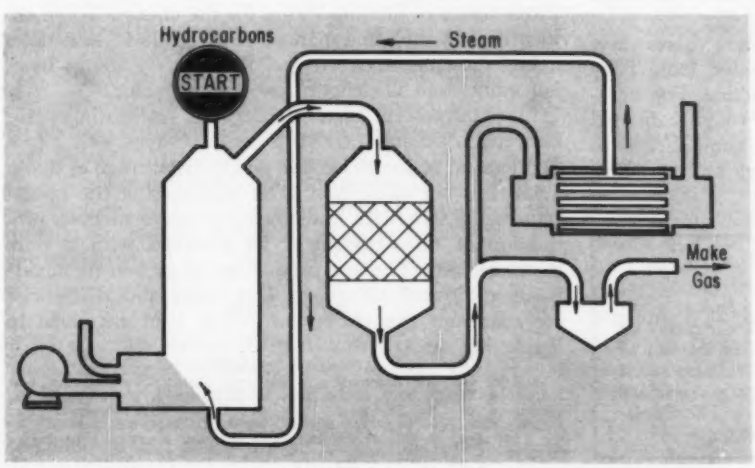


FIGURE 2—During the gas making phase (left), steam is combined with the hydrocarbon in thermal and catalytic reactions. The system goes through a "make" and "heat" cycle once about every five minutes.

full production, an output of 48-50 million cubic feet of town-gas is possible.

To assure the plant of having feedstock around-the-clock, a 24-inch high-pressure pipe line was laid to the Shell Haven refinery in 1957, with 12-inch spurs to Coryton and the Canvey Island in the Thames in 1958. This latter spur will bring in methane arriving liquefied by ocean shipments. The first such shipment was made in February 1959, by the "Methane Pioneer," a boat owned by the British Gas Council and Constock International Methane. Six shipments of 2,000 tons each have now been received.

The Romford plant consists of four units, each unit containing preheater, reactor, waste heat boiler, and washer as shown in Figure 1. These are followed by three scrubbers and three centrifugal turbines. Beyond them is the junction with the "cold enrichment" line. At this point, untreated refinery gases are added to bring up the heating value of the product to specification. Purification, metering, mixing and odorizing follow.

The operating system employed here is the self-steaming variant with alternating "make" and "blow" streams of gases moving in the same direction. A complete cycle takes 4 minutes and 50 seconds. It is divided as follows: heating phase, 33 percent; "make" purge, 4 percent; reforming phase, 59 percent and "blow" purge, 4 percent.

For successful operation and minimum carbon deposition, the amount of steam used is 0.112 pounds per cubic foot of gas, considerably over the calculated value of 0.0803 pounds per cubic foot. During the reforming phase refinery gas plus steam pass through the preheater for a very brief initial thermal reaction. This is followed by catalytic reforming in the reactor where the Ni_2O_3 and NiO are reduced in temperature range of 1,200°-1,500° F. The composition of the reactor atmosphere is controlled by excess air admitted during the heating phase when combustion of some of the gas is employed.

The plant is self-supporting in steam. From the waste-heat boilers steam at 570° F goes through centrifugal turbines which drive the air blowers. The exhaust steam at 20 psi is mixed with superheated steam to furnish charge for the process and steam at 120 psi for the rest of the gas works.

The feedstocks for the plant have heating values varying between 900 and 2,200 Btu per cubic foot. They have less than 0.5 ppm of hydrogen sulfide. For practical purposes the refinery gases can be roughly divided into three classes with the approximate compositions in Table 1. Feed "B" represents an average and is similar to ethane.

About the Author

Michael Swiss is an Associate Fellow of Institute of Petroleum (London) having studied chemical engineering at Birmingham University and chemistry at Borough Polytechnique (London). He has worked at the gasworks in Birmingham, England and was plant supervisor of Berry Wiggins and Company's refinery at Salford. Mr. Swiss also has worked for The Distillers Company Ltd. and Thomas Hill-Jones.

TABLE 1—Three Ranges of Feedstock

	A	B	C
Cal. val., Btu/cu ft.	2000	1500	1000
Spec. gr. (air = 1.0)	1.30	0.87	0.54
Composition, Vol %			
Hydrogen	0.5	22.0	56.0
Methane	22.0	22.0	12.0
Ethane	25.0	22.0	13.0
Propane	36.0	18.0	13.0
Butane	3.0	3.0	2.0
Ethylene	2.0	3.0	1.0
Propylene	9.0	7.0	1.0
Butylene	2.0	2.0	1.0
Nitrogen	0.5	1.0	1.0
C/H ratio	4.36	3.95	2.97

TABLE 2—Products from the Romford Plant

	REFORMED GAS (Not Enriched)			ENRICHED GAS		
Feed Type	A	B	C	A	B	C
Cal. val., Btu/cu ft.	292	294	244	500	500	500
Sp. gr. (air = 1.0)	0.42	0.43	0.49	0.51	0.51	0.51
Composition, Vol %						
Hydrogen	65.9	64.7	56.9	57.9	57.5	56.7
Carbon monoxide	18.0	16.8	12.6	15.8	13.9	8.3
Carbon dioxide	9.2	8.8	7.3	8.1	7.3	4.8
Oxygen	0.3	0.5	1.7	0.3	0.4	1.1
Nitrogen	3.9	5.7	19.2	3.5	4.9	13.0
Hydrocarbons	2.7	3.5	2.3	14.4	16.0	16.1

TABLE 3—Typical Thruput Quantities

	CUBIC FEET PER CYCLE		
Feed Type	A	B	C
Process gas	5,150	6,880	7,730
Heating gas	1,380	1,804	2,300
Cold enrichment gas	4,970	7,516	17,363
Gas produced	40,915	43,980	51,026
Efficiency, %			
Reforming	80.6	82.5	81.9
Over-All	89.0	90.6	93.4
Maximum Output, MMcf/d	12.2	13.1	15.2

By reforming about a half of the feed a product is achieved which has a much greater volume and is rich in hydrogen and carbon monoxide. The product has a heating value of only about 300 Btu per cubic foot. Thus the town-gas specification for a heating value of 500 Btu per cubic foot is achieved by adding the other half of the refinery gases to the gas plant product.

After nine months of continuous operation, by May 1959, it has been possible to assess the performance of the plant. The results are presented in Table 2 for the three ranges of heating values for the charge. These are identified in the same manner as in Table 1: A denotes a high heating value charge, B denotes medium heating value, and C denotes low heating value.

Over 80 percent of the feed gas has a heating value between 1,100 and 1,600 Btu per cubic foot with a preponderance of the richer gas giving an average of about 1,450 Btu per cubic foot. The efficiency of the operations using feed with lower heating values suggests production of town-gas might be achieved with a pure methane feed. The low production of carbon monoxide is an additional advantage. Gas ratios and efficiencies for reforming the three ranges of feed are given in Table 3.

ACKNOWLEDGMENT

Material for this summary was gathered from "The Romford Gas Reforming Plant" by J. Burns and E. R. Stewart, published by the Institution of Gas Engineers, 1959, and from "Shell Haven-Romford Refinery Gas Pipeline of the NTGB" by A. D. L. Copp, published by the Institution of Gas Engineers, 1958. Diagram courtesy Humphrey's, Glasgow.

How to Estimate Installed Pump Costs

These data permit rapid and accurate estimation of complete process pumping systems

N. H. Prater and D. W. Antonacci
The Chemstrand Corporation
Pensacola, Fla.

CENTRIFUGAL PROCESS pumping systems are one of the items of processing equipment most frequently encountered when making a preliminary cost estimate. The problem is further complicated when a variety of pump services are to be covered. Data presented here permits the cost of these pumping systems, including both equipment and installation costs, to be estimated with a minimum of time and effort.

Poorly prepared estimates result from many factors. These include incomplete specifications, lack of technical information and failure to understand the scope of the work being estimated. Unless sufficient technical information is developed to allow the completed installation to be visualized, additions or revisions to the estimate will occur as a result of after-thoughts.

Data presented here are not intended to replace the formal estimate prepared from detailed drawings and specifications. It will, however, allow reasonably accurate estimates to be prepared with a minimum of time and still include all the factors which contribute toward the cost of the process pumping system.

There are many standard types of centrifugal pumps used in the petroleum and chemical industry. For noncorrosive service, the most commonly used pump is the "standard fitted" pump which has a cast iron casing, bronze impeller, gland, and impeller wearing rings. For corrosive or abrasive types of service, or wherever contamination of the product must be avoided, special materials of construction must be employed. In general, bronze parts are not used for services operating above 250° F and cast iron is not used above 350° to 400° F. Alloys such as 11-13 percent chrome steels are frequently used when temperature above 400° F are encountered.

PUMP SIZE

A preliminary selection of the proper size pump for estimating purposes can be made using the data shown in Figure 1. Here the differential pumping head is plotted versus pump capacity in gpm for a number of standard type pumps. In all cases the pump shown does not include the maximum diameter impeller which can be furnished. This automatically provides a range of capacities and pumping heads approximately 15-25 percent above or below that shown which allows additional flexibility in selecting the lowest priced pump. After the preliminary selection is made, the approximate pump cost can be obtained from Table 1 where the price of standard fitted pumps is shown along with the price addition for special materials of construction.

TABLE 1—Approximate Cost of 1750 RPM Centrifugal Pumps

PUMP TYPE	Approximate Cost of 1750 RPM Centrifugal Pumps					
	Base Cost*	Additions To Standard Fitted Pump Costs				
	Standard Fitted	304 S/S Casing	316 S/S Casing	Monel Casing	Bronze Casing	Steel Casing
A	$ 375	$ 350	$ 385	$ 420	$ 200	$ 200
B	450	490	540	585	280	280
C	575	735	810	885	420	420
D	625	735	810	885	420	420
E	950	1,050	1,150	1,260	610	610
F	1,050	1,200	1,320	1,440	690	690
G	1,525	1,675	1,830	2,000	960	960
H	1,900	2,000	2,200	2,400	1,150	1,150
I	2,225	2,450	2,700	2,950	1,400	1,400
J	2,350	2,550	2,800	3,050	1,475	1,475
K	3,300	4,600	5,050	5,500	2,650	2,650
L	6,000	6,800	7,500	8,150	3,900	3,900

* Includes flexible coupling, bronze impeller, bronze glands, bronze shaft sleeves, bronze wearing rings and packed stuffing box.

CAPACITY VARIABLES

Most centrifugal pumps are rated on water pumping applications and the water efficiency of each pump classification, A through L, is shown in Figure 2. All deviations from this theoretical ideal liquid represent a reduction of pump capacity and efficiency. The data shown in Figure 3 is used to convert the water ratings to viscous material ratings. Various water peak efficiencies and viscosities of the material to be pumped are shown as parameters.

As an example of how this data is used, suppose a centrifugal pump is available with a capacity rating of 1,000 gpm at 125 feet head. From Figure 1, this would be a type "F" pump. Referring to Figure 2, the peak efficiency is 85 percent while the efficiency at the op-

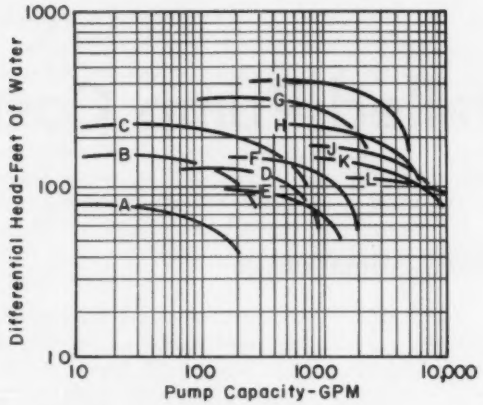


FIGURE 1—Shows centrifugal pump selection curves for 12 types of pumps. See Table 1 for approximate costs.

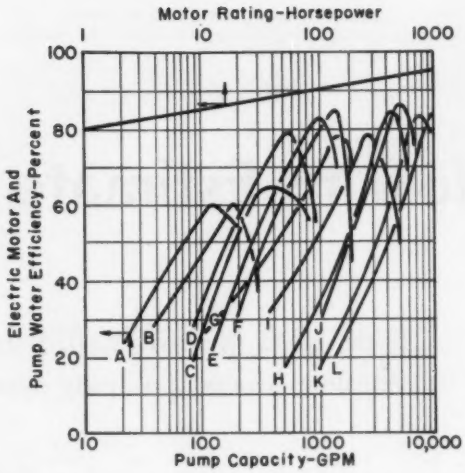


FIGURE 2—These are the water pumping efficiencies for the 12 types of pumps.

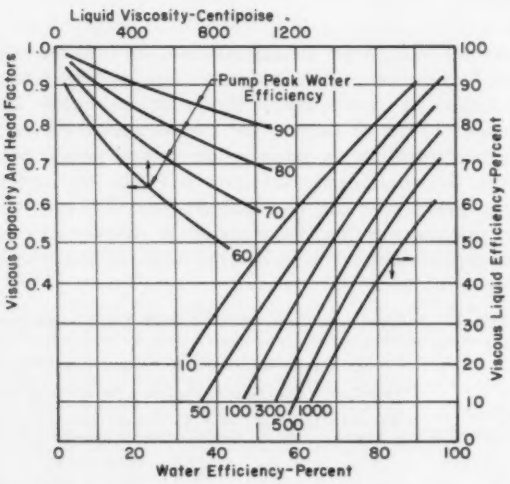


FIGURE 3—Here's how changes in liquid viscosity affect pump performance.

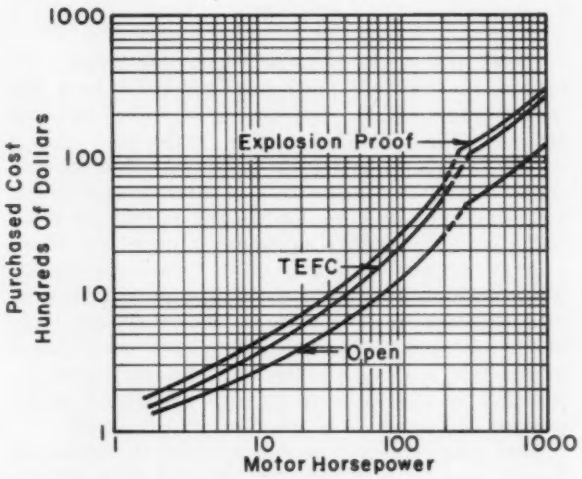


FIGURE 4—These costs are for 1800 rpm, squirrel cage induction motors. 440 volts up to 250 hp and 2300 volts above this rating.

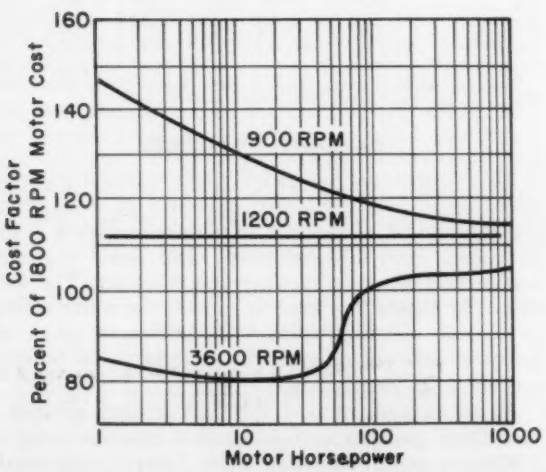


FIGURE 5—Use these cost correction factors for motor speeds other than 1800 rpm.

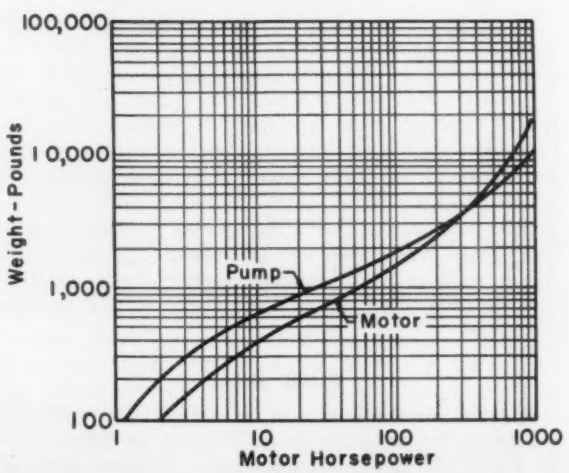


FIGURE 6—Use these estimated weights for motors and pumps in checking foundation loadings.

erating point is 80 percent. It is desired to use this pump for transporting oil of 600 centipoise viscosity and a specific gravity of 1.0. What will be the maximum head, capacity and power requirements at this point?

From Figure 3, the capacity and head correction is found to be 0.83. Also from Figure 3, the viscous efficiency is found to be 48 percent.

$$\text{New Capacity} = 1{,}000 \times 0.83 = 830 \text{ gpm}$$

$$\text{New head} = 125 \times 0.83 = 104 \text{ feet}$$

$$\text{Brake horsepower} = \frac{\text{GPM} \times \text{Head, ft.}}{3960 \times \text{efficiency, \%}} = \frac{830 \times 104}{3960 \times 0.48} = 45 \qquad \text{Eq. 1}$$

The Reynold's number plays a significant role when handling viscous liquids. Exhaustive tests on many types of pumps have yielded correction factors which can be applied. These factors are correlated with Reynold's number and are given in the Standards of the Hydraulic Institute.[1] In actual practice, the correction factors for head and capacity differ somewhat but have been shown as being the same in Figure 3 for convenience.

SPECIAL FEATURES

In many cases, the standard fitted pump may require special features such as a water cooled stuffing box, different operating speed or high operating pressures. The additional cost of providing special features can be approximated by adding the appropriate additions to the base pump costs shown in Table 2. This table is not all inclusive but it does present the more common types of "extras" encountered in the usual process pump services.

TABLE 2—Approximate Additions to Base Pump Costs for Special Pump Features

SPECIAL FEATURES	Additions to Base Pump Costs
Open Impeller	25%
Type 304 S/S Wearing Rings on Casing or Impeller	10%
Type 304 S/S Impeller	20%
Type 316 S/S Impeller	21%
Monel Impeller	22%
Type 304 S/S Shaft Sleeves	10%
Water Cooled Stuffing Box (Types A thru D)	$65
Water Cooled Stuffing Box (Types E thru L)	$135
Water Cooled Bearings (Types A thru D)	$100
Water Cooled Bearings (Types E thru L)	$170
Operating Pressure from 175 to 250 PSIG	15% but not less than $170
1150 RPM Pump Speed (Same capacity & head)	35%
860 RPM Pump Speed (Same capacity & head)	60%
Certified Test Performance Curves	5% but not less than $35
Witness Test At Factory Plus Certified Test Curves	10% but not less than $60

SPARE PARTS

In many instances, the cost of spare parts or equipment replacement items must also be included in preliminary estimates. These costs and recommended quantities can be obtained from the pump manufacturer. However, for preliminary estimates, the designer or estimator must exercise individual judgment for each case. Table 3 gives the approximate cost of replacement parts as a percentage of a complete pump cost exclusive of the motor, for both normal and heavy duty service. Normal duty refers to pumps designed for low heads and low horsepower ratings.

TABLE 3—Approximate Cost Factors for Major Pump Components as Percentage of Base Pump Costs

COMPONENT	Normal Duty	Heavy Duty
Coupling	2	3
Base Plate	6	10
Pump Casing	60	30
Impeller	5	12
Shaft	10	10
Glands	3	7
Bearings	2	4
Shaft Sleeves	2	4
Frame	5	15

MOTORS

The induction motor is by far the most widely used motor in the process industries. The accepted standard motor has a rotor which resembles a revolving squirrel cage and has thus been termed the "squirrel-cage" motor. It is sturdy and unsurpassed in economy over a wide range of horsepower.

By altering the design of the rotor, it is possible to provide motors with high or low starting torque and slip. This provision, however, increases the motor cost approximately 5 to 10 percent. Usually an induction motor with normal torque and starting current is employed. The cost of this type motor designed for 1800 rpm speed is shown in Figure 4 for motor sizes from 1 to 1,000 horsepower.[2]

The type of motor enclosure has a considerable effect on the motor cost. The data in Figure 4 also reflects the cost of the motor enclosure normally used. The motor voltage selected for motors up to 250 horsepower, is 440 volts while motors shown between 250 and 1,000 horsepower are rated for 2300 volts.

The most economical induction motor speed is generally 3600 rpm for motors below 75 horsepower. For motors between 75 and 2,000 horsepower, the 1800 rpm speed induction motor is the least expensive selection. In many instances, however, other operating speeds are desired and the data shown in Figure 5 may be used to correct the cost of 1800 rpm motors shown in Figure 4.

FOUNDATIONS

All pumps and motors regardless of type require foundations capable of absorbing the vibrations created during operation as well as supporting the equipment weight. The periphery of the support should conform to the periphery of the equipment and the foundation base must extend to firm soil structure. Small pumps and motors usually have a low mass/area ratio and

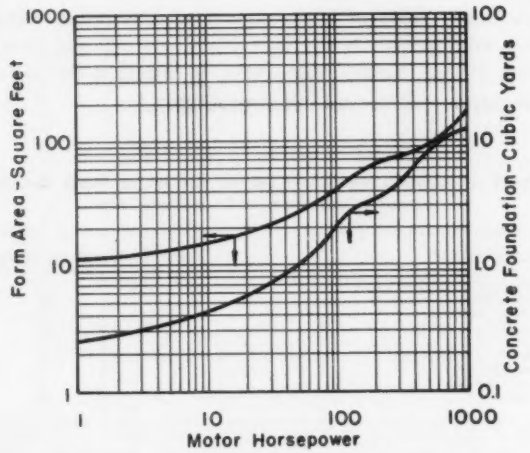


FIGURE 7—Here total quantity of concrete and form area for foundations are plotted versus motor horsepower.

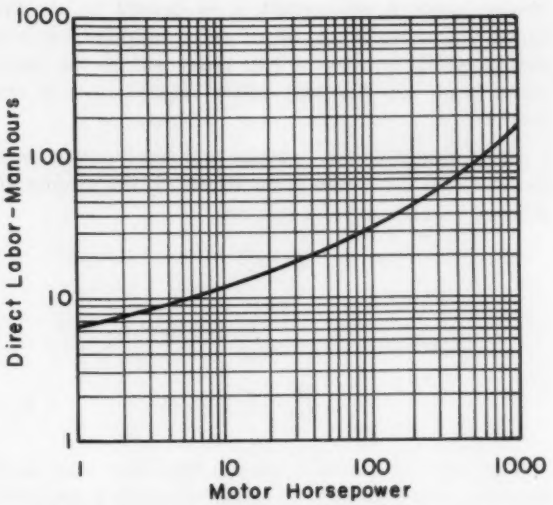


FIGURE 8—Take total labor for foundation preparation from this chart.

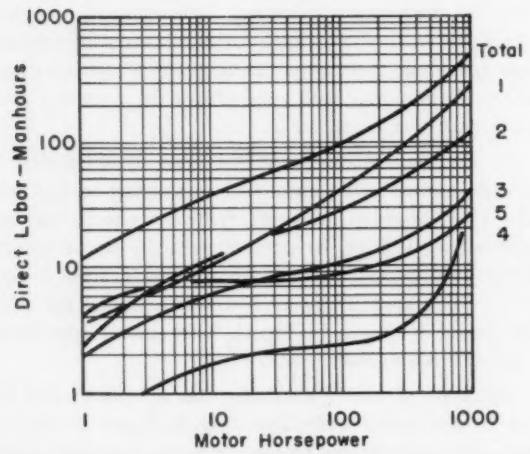


FIGURE 9—These labor manhours include (1) set motor, (2) set pump, (3) haul, (4) unload and (5) equivalent machine hours for installing both pump and motor.

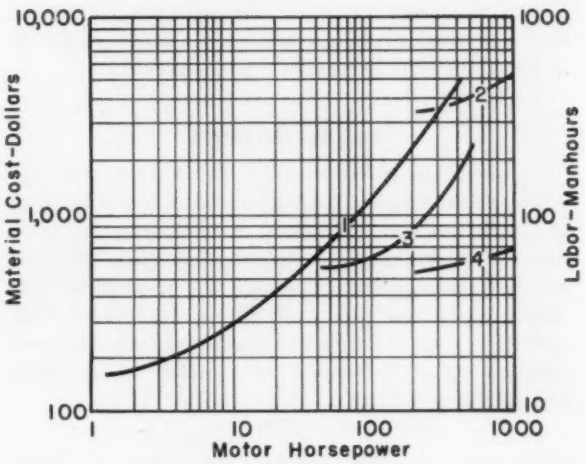
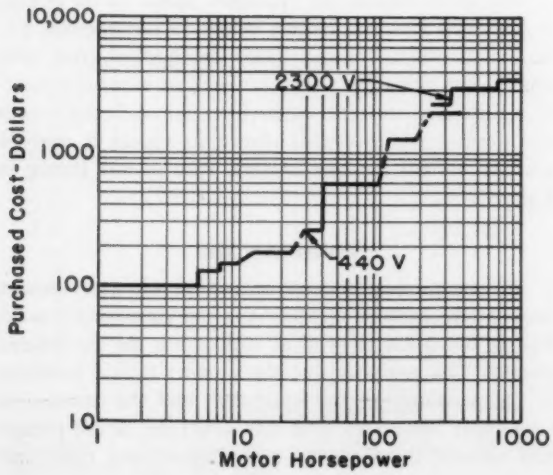


FIGURE 10—These are total material costs and labor manhours for electric motor service. (1) Material costs, 440 volt system, (2) Material costs, 2300 volt system, (3) Labor, 440 volt system and (4) Labor, 2300 volt system.



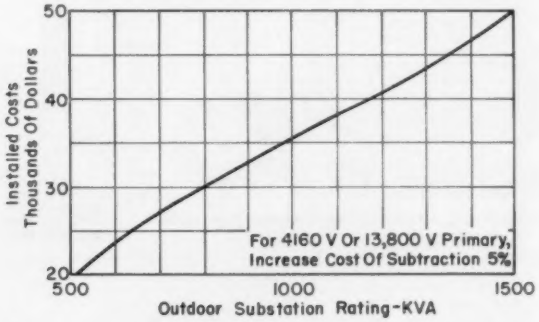


FIGURE 11—These costs (left) are for 440 volt and 2300 volt general purpose enclosure combination air circuit breaker and magnetic starters.

FIGURE 12—Use these approximate costs (above) for 2300 volt primary, 480 secondary outdoor substations.

the unit soil loading is almost always below the load bearing capacity because of the large foundation area. Estimated weights of typical pumps and motors which can be used for checking foundation loadings are shown in Figure 6.

Process pumps and motor drives are usually located at grade level and set on separate raised concrete foundations. The foundation top should be a minimum of six inches above the normal area grade level. Approximately one inch of space should be allowed for grout between the equipment base plate and the foundation top. The major cost item in foundation construction is the labor cost for building and setting the forms. Therefore, costs can be reduced by using simple concrete shapes and foundation dimensions based on standard lumber sizes or metal forms, if used. The total quantity of concrete and the form area for the average pump and motor foundation can be estimated from the data given in Figure 7, and the total labor manhours required for preparing these foundations is given in Figure 8. These data have been prepared for process pumping systems up to 1,000 horsepower motor ratings. The factors required in arriving at total foundation costs are shown in Table 4.

TABLE 4—Estimating Factors for Pump and Motor Foundation Labor Shown in Figure 4

Excavation—Outside by Hand:	
Packed Soil	3 manhours/cubic yard
Average Soil	2 manhours/cubic yard
—Outside by Machine	0.25 manhours/cubic yard
Disposal—6 mile haul	0.25 manhours/cubic yard
Backfill and Compact—by Hand	0.75 manhours/cubic yard
Set Anchor Bolts Templates Sleeves:	
¾ inch diameter	0.17 manhours each
1 inch diameter	0.20 manhours each
2 inch diameter	0.30 manhours each
Concrete, Place and Vibrate	1.75 manhours/cubic yard
Grouting—Special	4 manhours/square yard
Average (1" thick)	2 manhours/square yard
Reinforcing Steel:	
Unload, sort, bend, place and tie	0.02 manhours/pound
Forms:	
Make-up, erect, strip, clean and move	0.3 manhours/square foot

ERECTION

The equipment foundations are poured as soon as underground piping and electrical conduit work in the immediate area is finished. Then the erection or equipment installation is started. This includes hauling the equipment to the site, unloading and setting the equipment in place. This operation is commonly referred to as "rigging," and is accomplished through the use of cranes, derricks, gin poles or even chain hoists depending upon the weight of the equipment to be installed. The total labor requirements for these operations are shown in Figure 9 for both pump and motor versus motor horsepower. The equivalent machine hours were derived by assuming an average rate of eight dollars per hour for machine time.

ELECTRICAL SERVICE

Primary distribution voltages usually found in refining or chemical plants are 2400 volts, 4160 volts, and 13,800 volts. The voltage selected is a function of both load density and in individual motor ratings. An analysis of the total cost of motors, motor controls, low voltage substation and power cable costs will determine the most economical motor voltage to be selected. In general, 440 volt motors are used for horsepower ratings up to 250 hp and 2300 volt motors are selected for horsepower rating between 250 and 1,000 horsepower. The total material cost and labor required for electrical motor service costs are shown in Figure 10.

The costs shown are for non-hazardous locations where the safety switches and switchgear are located in a ventilated switchroom. The total costs include combination air circuit breakers and magnetic starters, push buttons, 100 feet of conduit and flexible connection at the motors. Various selections of motor starters are available, depending on the degree of protection required, a preference for oil or air-break equipment and the interrupting capacities involved. The interrupting capacities of the 440 volt controllers are 15,000 to 25,000 rms amperes and high interrupting capacity circuit breakers are seldom required. In the case of 2300 volt and higher motor controllers, the interrupting capacity and instantaneous rating becomes critical since the motor service is generally taken directly from the distribution system. The cost of general purpose 440 and 2300 volt starters is shown in Figure 11. For high interrupting capacity 2300 volt starters, the costs shown should be increased approximately 25 percent. In addition, all starter costs should be increased 35, 75, 200 and 275 percent for dust-tight weatherproof, explosion-proof (dusts) and explosion-proof (vapor) enclosures, respectively.

ELECTRICAL SUBSTATION

It is rarely economical to install a 480 volt distribution system for 440 volt motor service and it is necessary to install a 480 volt transformer substation to reduce the high voltage distribution. In many instances, the cost of the substation is included in the cost of the process pumping system. Figure 12 shows the installed cost of 480 volt outdoor substations which can be used for estimating total costs or for allocating a proportion of the substation cost in the total cost of the 440 volt motor installation.

EXAMPLE

Estimate the installed cost of a centrifugal pump to transport 2,000 gpm of oil having a viscosity of 500 centipoise and a specific gravity of 1.0 at a pumping temperature of 400° F. The differential pumping head is 250 feet of liquid. The motor will be installed in a hazardous location while the motor controls will be housed in a ventilated switchroom.

Step 1. From Figure 1, a type "H" or "I" centrifugal pump is indicated. Since a viscous fluid is being handled, the type "I" pump will be selected. Referring to Figure 2, the water efficiency is 78 percent while the efficiency of the operating point is 70 percent. From

Figure 3, the capacity and head correction when pumping a liquid of 500 centipoise viscosity is 0.81. Also from Figure 3, the viscous efficiency is found to be 34 percent.

Step 2. Check pump selected for head and capacity when handling viscous fluids.

$$\text{New Head} = \frac{250}{0.81} = 309 \text{ feet of liquid}$$

$$\text{New Capacity} = \frac{2{,}000}{0.81} = 2{,}469 \text{ gpm}$$

Referring again to Figure 1, the type "I" pump is adequate but a smaller diameter impeller should be chosen. Since a relatively high pumping temperature is required, type 304 stainless steel will be selected as the material of construction and a water cooled stuffing box will be employed. The cost of the pump from Table 1 is as follows:

Cost of Standard Fitted 1750 rpm Type "I" Pump	= $2,225.00
Addition for Type 304 S/S	= 2,450.00
Addition for Water Cooled Stuffing Box (from Table 2)	= 170.00
Total Pump Cost	= $4,845.00

Step 3. Determine motor horsepower required from Eq. 1.

$$\text{BHP} = \frac{2{,}000 \times 250}{3{,}960 \times 0.34} = 371$$

From Figure 2, the approximate motor efficiency is 93 percent

$$\text{Motor hp required} = \frac{371}{0.93} = 399 \text{ hp use a 400-hp motor}$$

The cost of a 400-hp, 1,800-rpm explosion-proof motor from Figure 4 is: $16,000.00

Step 4. Determine foundation requirements and costs: From Figure 7, the foundation for a 400 hp pump and motor requires 6.5 cubic yards of concrete and a foundation form area of 95 square feet. From Figure 8, the total labor required to prepare the complete foundation including excavation, forming, pouring concrete, installing reinforcing steel, setting anchor bolts, grouting, removing forms and backfill is 75 manhours.

Total Foundation Costs:

Forms: 95 square feet @ $0.42/sq. ft.	= $ 39.90
Concrete: 6.5 cubic yards @ $14/cu. yd.	= 91.00
Reinforcing Steel: 485 lbs. @ $0.085/lb.	= 41.22
Anchor Bolts: $20/set	= 20.00
Total Material Cost	= $192.12
Labor: 75 manhours @ $3.50/hr.	= 262.50
Total Foundation Cost	= $454.62
	Say = $455.00

Step 5. Estimate total labor required to set pump and motor on foundation: From Figure 9 the total labor is 230 manhours. A breakdown of the total labor required is also shown in Figure 9.

Cost: 230 manhours @ $3.75/hr.	= $862.50
	Say = $863.00

Step 6. Estimate the total material and labor required for the electrical power wiring, switchgear and controls. A 2300 volt system will be employed. From Figure 10:

Material Cost: (power wiring, switchgear & controls)	= $3,950.00
Labor: 57 manhours @ $3.75/hr.	= 213.75
Total Electrical Costs	= $4,163.75
	Say = $4,164.00

Summary of Direct Installed Costs

2,000-gpm, 300 S/S Centrifugal Pump	= $ 4,845.00
400 hp, 1,800-rpm, explosion-proof electric motor	= 16,000.00
Foundation	= 455.00
Pump and Motor Installation	= 863.00
Electrical Service	= 4,164.00
Total Direct Cost	= $26,327.00

No allowance has been included for overhead and freight costs since these will vary with each location. In addition, the cost for insulation required on the pump must be added.

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ACKNOWLEDGMENT

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About the Authors

Prater

Antonacci

N. H. Prater is a senior design engineer with The Chemstrand Corp., Pensacola, Fla., where he handles design of new facilities and project engineering. Holder of a B.S. degree in chemical engineering from Georgia Institute of Technology, he previously worked for Magnolia Petroleum Co., Beaumont, Texas, doing design work in distillation, economic evaluations, and scheduling refinery operations. He has written other excellent articles for Petroleum Refiner.

D. W. Antonacci is a design engineer for The Chemstrand Corp., Pensacola, Fla., where he handles the design of utility and services facilities. Holder of a B.S. degree in mechanical engineering from Tri-State College, he was previously with Dravo Corp. as an engineer, construction engineer, mechanical superintendent, construction superintendent and assistant project manager for the design and construction of power plants, water treating plants, oil pumping stations, etc. A registered mechanical engineer, he has been with Chemstrand since 1955.

PART 19

Automation Today

The root locus plot offers a valuable graphical technique for studying a control system. Here is how the method works

Theodore J. Williams and Verlin A. Lauher
Monsanto Chemical Company, St. Louis

THE GRAPHICAL TECHNIQUE of plotting the closed loop poles of a system known as the *root locus plot* comprises another study method which is very valuable in control system analysis. It was originated and developed in 1948 by W. R. Evans[1] and has later been described in greater detail by many other authors. J. G. Truxal's description[2] is one of the many good, clear developments available. This part of our series will serve to introduce the techniques required to plot the root locus and present the basic theory associated with its development.

The root locus method is important since it is the easiest way of finding the closed loop poles of any control system, if the open loop poles are known. The reverse method, that of finding the open loop poles from the closed loop poles, can also be developed, but it is not of interest to us at the present time.

The terms "pole" and "zero," which are necessary in a discussion of the root-locus method, can be defined by the following examples:

Consider the transfer function

$$G(p) = \frac{p+1}{(p+3)\ (p+7)}$$

If we now let $p = -3$, then

$$G(-3) = \frac{-3+1}{(-3+3)\ (-3+7)} = \frac{-2}{(0)\ (4)} = \infty$$

In other words, the function, $G(p)$, evaluated at $p = -3$ has a value of infinity. This is called a "pole" of the function $G(p)$. By inspection it is apparent that the point, $p = -7$, is also a "pole" of the function, likewise, any other value which might make $G(p) = \infty$ would be a pole.

Now consider the case when $p = -1$, or $G(-1) = \frac{-1+1}{(-1+3)\ (-1+7)} = 0.$

All values of p which makes the function $G(p) = 0$ are called "zeroes" of the function.

The standard method of representing poles on the root-locus graph is by a small cross. Zeroes are represented by a small circle. A plot of the poles and zeroes of this function is shown in Figure 127.

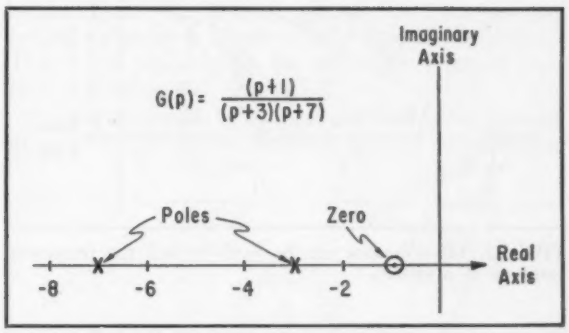


FIGURE 127—The standard method of representing poles on the root-locus graph is by small crosses. Zeroes are represented by small circles.

Another convenient definition of the root locus method is: *the root loci are plots of the variations of the poles of the closed loop transfer function with changes in open-loop gain.* The root locus plot allows a correlation of both *frequency response* and *transient response* on one diagram. In fact, *both* the *open* loop and *closed* loop *frequency response* may be developed from this one diagram.

THE OPEN LOOP FREQUENCY RESPONSE AS RELATED TO THE ROOT LOCUS

Let us consider the typical open loop transfer function, $G(p) = \frac{K}{(T_1 p+1)\ (T_2 p+1)}$ which we have used in previous discussions. As written, this transfer function represents two simple mixing vessels connected in cascade and controlled by a proportional only composition controller. T_1 and T_2 are the time constants of the two mixing vessels. For convenience, it is helpful to rearrange the transfer function into a more meaningful form. This consists of factoring out T_1 and T_2. Then

$$G(p) = \frac{K}{(T_1 p+1)\ (T_2 p+1)} = \frac{K}{T_1 T_2} \frac{1}{(p+1/T_1)\ (p+1/T_2)} = \frac{K\,\omega_1\,\omega_2}{(p+\omega_1)\ (p+\omega_2)}$$

In the last expression, $1/T_1 = \omega_1$ and $1/T_2 = \omega_2$.

These are the so-called "break frequencies" of the transfer function. If we now let $p = j\omega$ (where ω without a subscript represents any arbitrary frequency) and plot the factors as vectors, we obtain the result shown in Figure 128.

If ω is allowed to vary along the imaginary axis, the open loop frequency response will be obtained. The magnitude ratio at any frequency is always

$$|G(p)| = \frac{K}{T_1 T_2} \left| \frac{1}{(\omega_1 + j\omega)\ (\omega_2 + j\omega)} \right| = \frac{K}{T_1 T_2} \frac{1}{\sqrt{\omega^2+\omega_1^2}\ \sqrt{\omega^2+\omega_2^2}}$$

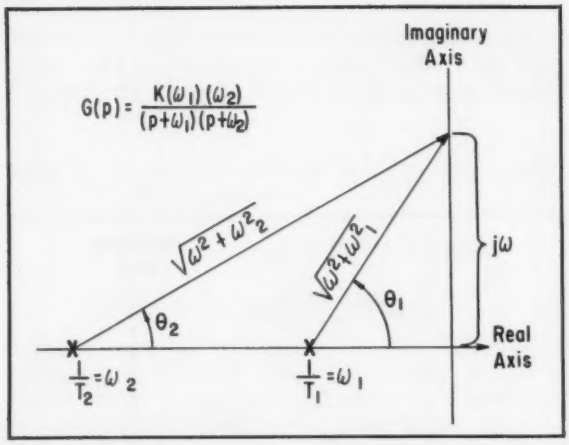


FIGURE 128—Vectors can be used to find the frequency response of a system.

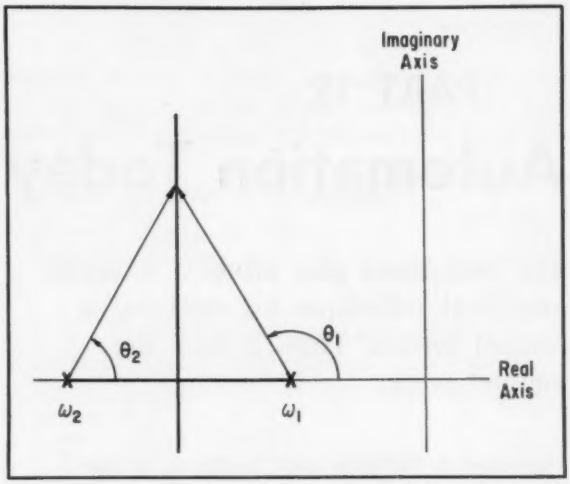


FIGURE 129—The locus of all possible roots may be obtained graphically without knowledge of the gain (K).

The total phase shift is given as, $\Theta_T = \Theta_1 + \Theta_2$.

Notice that for zero frequency

$$|G(p)| = \frac{K}{T_1T_2\sqrt{\omega_1^2}\sqrt{\omega_2^2}} = \frac{K}{T_1T_2\omega_1\omega_2} = K \text{ and } \Theta_T = 0$$

THE ROOTS OF THE CLOSED LOOP TRANSFER FUNCTION

If p is now allowed to be a complex function of frequency rather than simple $j\omega$ (the real frequency), the frequency, p, can be located anywhere in the complex plane. With this freedom available, a point (or series of points) may be located where $\Theta_1 + \Theta_2 = 180°$. It will now be proven that this is a necessary criteria for the solution of the roots (poles) of the closed loop system.

In an earlier article, Part 18, it was shown that the closed loop transfer function is

$$\frac{C}{R}(p) = \frac{G(p)}{1+G(p)}$$

where $G(p)$ is the open loop transfer function.

Since the denominator $1 + G(p)$ represents the "characteristic equation" of the system, the roots of this equation when set equal to zero are the poles of the closed loop transfer function.

Since $1 + G(p) = 0$ or $G(p) = -1 = -1.0 \angle 180°$, then the roots of $G(p)$ must yield a magnitude ratio of unity at an angle of 180° in order to be roots of the closed loop function. By using the fact that $\angle G(p) = 180°$ for solution of its roots, it is possible to locate points in the "p" plane for various values of p which satisfy this requirement, $G(p) = -1$. If all such points are located, a locus of all possible roots will result.

Figure 129 shows a plot of such roots for the foregoing example. Notice the system is stable for all values of gain because the loci never crosses the imaginary axis (i.e., the root always have a positive real part). In order to plot this path, K (gain) must have varied in value which is what should be expected since K is usually a variable parameter in a control system. Since in this case $G(p) = \frac{K\omega_1\omega_2}{(p+\omega_1)(p+\omega_2)} = -1$, each value of K serves to specify a new pair of roots of the function $G(p)$.

The case just illustrated is simple enough that the roots of p can also be found by using the quadratic formula. However, this is a very laborious operation if many values of K are used. It will be pointed out that on the root locus plot, all possible roots may actually be obtained without a knowledge of K.

RULES FOR THE CONSTRUCTION OF ROOT LOCUS PLOTS

Some simple rules for the construction of root locus will now be developed. With these rules available, it is possible to sketch the root locus without going through the complete graphic operations to find values of p for which the sum of the vector angles equals 180°.

Rule 1. For $K \to 0$—If $G(p)$ is written as $G(p) = K\,G_1(p)$ then anywhere on the loci of roots, $K\,G_1(p) = -1$. If K approaches zero then $G_1(p)$ must approach infinity. Thus p approaches the poles of $G_1(p)$. Therefore, since the root locus is interpreted as a plot of the closed loop pole positions when the open loop gain varies from zero to infinity, the loci must start from the open loop poles.

Rule 2. For $K \to \infty$—Clearly $K\,G_1(p) = -1$ indicates that for very large values of K, $G_1(p)$ approaches zero or p is approaching a zero of $G_1(p)$. Then the loci must terminate on zeroes of $G_1(p)$.

Rule 3. Number of Loci—Since all loci originate from open loop poles, then the number of loci equals the number of finite poles.

Rule 4. Symmetry of the Root Locus—The complex parts (any point not lying on the real or imaginary axis) of the loci must appear in complex conjugate pairs (i.e., the locus is symmetrical about the real axis).

Rule 5. Loci near Infinity—If we replace the numerator and denominator of a general transfer function, $G(p)$ by their largest values (valid for very high fre-

quencies), then $G(p) = K\frac{p^m}{p^n} = K\left(\frac{1}{p^{n-m}}\right) = -1$ where m is the highest order of the zeroes and n is the highest order of the poles. For large values of K, the loci approach asymptotes at angles of $\pm 180/n\text{-}m$; $\pm 540/n\text{-}m$; $\pm 900/n\text{-}m$, etc. For a case of n-m = 3, the loci approach infinity at 60°, —60°, and 180°; for n-m = 4, at angles of 0°, 90°, 180°, 270°. When the asymptotes are extrapolated back to the point of intersection, they do not in general approach the origin. The point of intersection on the real axis is:

$$\frac{\text{sum of values at poles} - \text{sum of values at zeroes}}{\text{number of finite poles} - \text{number of finite zeroes}}$$

Rule 6. Loci on the Real Axis—The locus must always have a total angle of 180° from the poles and zeroes to any point on the loci. Therefore, that portion of the real axis to the left of an odd-numbered pole or zero is part of the root locus.

Rule 7. Intersection of the Imaginary Axis—That value of ω necessary to have the loci intersect the imaginary axis may be found by letting $p = j\omega$. Then $G(p) = G(j\omega)$ and $G(j\omega) = -1$. Solve the resulting equation for ω by setting the imaginary part equal to zero.

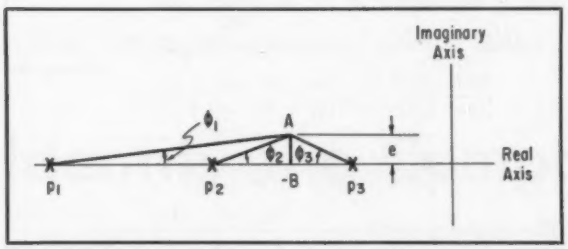


FIGURE 130—Here is the graphical significance of the breakaway point (—B).

Rule 8. Point of Breakaway from the Real Axis—In Figure 130, three poles (p_1, p_2, and p_3) are plotted. Assume a point A, slight above the real axis at a value of —B on the real axis. Then the angles to the point A are Φ_1, Φ_2, Φ_3 and their sum must equal zero degrees to be a point on the locus [zero degrees result rather than 180° because $\Phi_1 + \Phi_2 + (180° - \Phi_3) = 180°$]. Small angles may be replaced by their appropriate tangents resulting in the new identity

$$\frac{e}{p_1 - B} + \frac{e}{p_2 - B} - \frac{e}{B - p_3} = 0.$$

By cancelling e, the value of B may be found by trial and error.

An example is given in the accompanying box to show how these rules are applied.

CALCULATION OF GAIN ON THE ROOT LOCUS

The value of gain (K) may be determined graphically from the root locus plot. Suppose a value of K is desired to yield an optimum transient response. In the previous article (Part 18), a value of δ (damping factor) for a good transient response of a second order system was found to be $\delta = \cos 69° = 0.36$. It may be proven that if all but two poles are remotely located from the imaginary axis, then these two poles may be considered to be the predominate poles of the system. Such a system will behave like a second-order system, although the transfer function is actually of an order much higher than two.

For an example of how the gain can be determined, the same problem as defined in the accompanying box will be used. First, construct a 69° line (i.e., $\delta = 0.36$) as in Figure 131. Where this line intersects the loci locates the point q_1 (a closed loop pole of the system). This is the pole location for which the value of gain, K, is desired.

Construct vectors from the open loop poles (located at —1, —2, —4) to the point q_1. The magnitude of

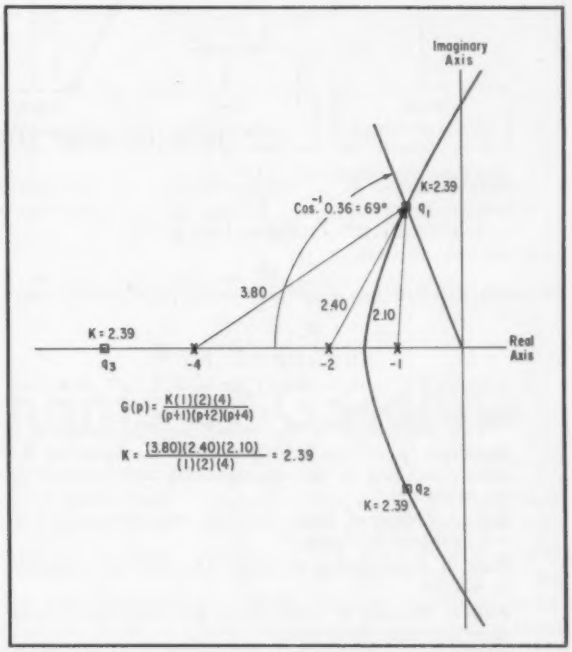
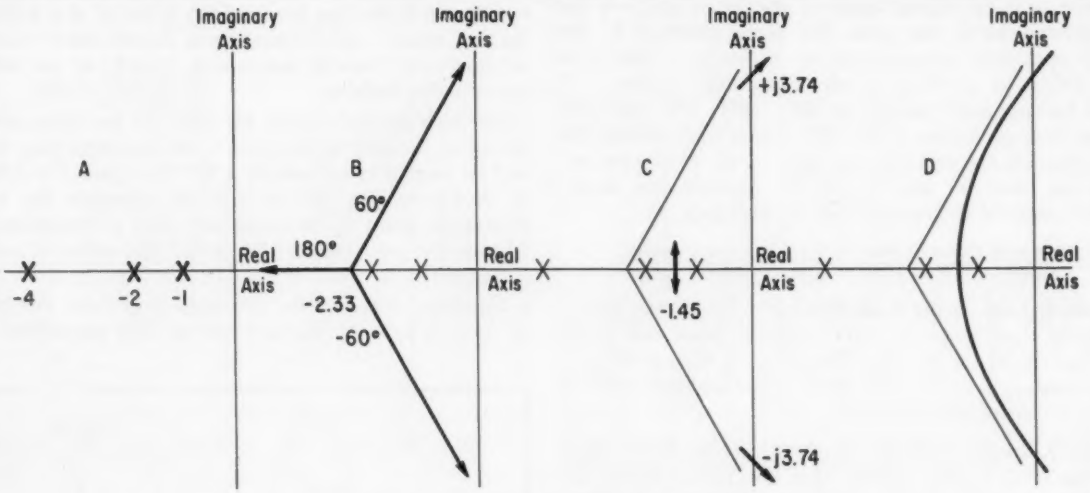


FIGURE 131—The value of the gain (K) may be determined graphically from the root locus plot.

these vectors is now determined by measuring their lengths. At any point on the root locus, K is determined by the relation $K = \frac{1}{|G_1(p)|}$, ($|G(p)| = |KG_1(p)| = |-1|$). Therefore, $K = \frac{(3.80)(2.40)(2.10)}{(1)(2)(4)} = 2.39$. The other two poles ($q_2$, q_3) are located in a like manner (i.e., q_2 by symmetry and q_3 by requiring the vector magnitude product divided by 8 to equal 2.39). This value of K then locates all the closed loop poles and produces the transient response desired. These closed loop poles are located on Figure 131 and are designated as small squares.

Knowing the location of the closed loop poles now allows the development of the closed loop frequency response. The procedure for plotting this response is the same as that described for the *open* loop frequency response. The only difference is that the *closed* loop poles are used instead of the *open* loop poles. The transient



HOW TO MAKE THE ROOT LOCUS PLOT

Consider the function $G(p) = \frac{K}{(T_1p+1)(T_2p+1)(T_3p+1)} = \frac{K}{(T_1T_2T_3)(p+1/T_1)(p+1/T_2)(p+1/T_3)} = \frac{K(1)(2)(4)}{(p+1)(p+2)(p+4)}$

Where $1/T_1 = \omega_1 = 1$; $1/T_2 = \omega_2 = 2$; $1/T_3 = \omega_3 = 4$ radians/unit time.

The polynomial of the closed loop denominator is therefore $(p+1)(p+2)(p+4) + K$. Applying the rules developed in the accompanying article results in the following:

Rule 1. Origin of Loci—The loci start from —1, —2, —4 as shown in Figure A.

Rule 2. Termination of Loci—The loci all terminate at infinity.

Rule 3. Number of Loci—There are three loci because there are three finite poles.

Rule 4. Symmetry of Root Locus—For all values of K there is at least one real portion. The other two loci may be real or complex conjugates.

Rule 5. Loci Near Infinity—Because all zeroes are at infinity, the three loci must approach infinity at 60°, —60° and 180°, $\frac{(\pm 180)}{n-m} = \frac{\pm 180}{3} = 60°$

Figure B indicates the location of the ends of the asymptotes. The point of intersection of the asmyptotes becomes $\frac{(-1-2-4)-0}{3-0} = -2.33$.

Rule 6. Loci on the Real Axis—The loci on the real axis appear to the left of odd-numbered poles (i.e., between —1 and —2 or to the left of —4).

Rule 7. Intersection of the Imaginary Axis

$$G(p) = G(j\omega) = \frac{8K}{(j\omega+1)(j\omega+2)(j\omega+4)} = \frac{8K(-j\omega+1)(-j\omega+2)(-j\omega+4)}{(j\omega+1)(j\omega+2)(j\omega+4)(-j\omega+1)} = \frac{(-j\omega+2)(-j\omega+4)}{8K(j\omega^3-7\omega^2-14j\omega+8)} = \frac{8K(j\omega^3-7\omega^2-14j\omega+8)}{(\omega^2+1)(\omega^2+4)(\omega^2+16)}$$

The imaginary part is $j\frac{8K(\omega^3-14\omega)}{(\omega^2+1)(\omega^2+4)(\omega^2+16)}$.

Setting the imaginary part equal to zero yields $8K(\omega^3-14\omega) = 0$, or $\omega^2 = 14$ and $\omega = \pm 3.74$. These points are shown on Figure C.

Rule 8. Point of Breakaway from the Real Axis—Using the tangent of the angle relationship yields $\frac{e}{4-\alpha} + \frac{e}{2-\alpha} - \frac{e}{\alpha-1} = 0$. Clearing the fractions and eliminating e this equation becomes $3\alpha^2 + 14\alpha - 12 = 0$. Solving for α by the quadratic formula gives roots of —1.45 and —3.32. The point —3.32 is impossible (does not lie on the locus). Therefore, the breakaway point is —1.45. The location of the breakaway point also is shown in Figure C.

The Complete Plot—The complete root locus may now be sketched by combining the results obtained from the above eight rules. The resulting complete sketch is shown in Figure D.

response is known because the value of δ (damping factor) has been specified. The system is now completely defined.

Transient response, open loop frequency response, and closed loop frequency response are all known from the information displayed on the root locus plot. By inspection of the root locus it is possible to see how transient and frequency response will change with different values of gain. We see then that the root locus plot condenses much information onto one diagram for rapid inspection allowing quick design analysis.

The next article of this series will provide additional examples and more graphic techniques which are useful in quickly designing a good control system.

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TO BE CONTINUED

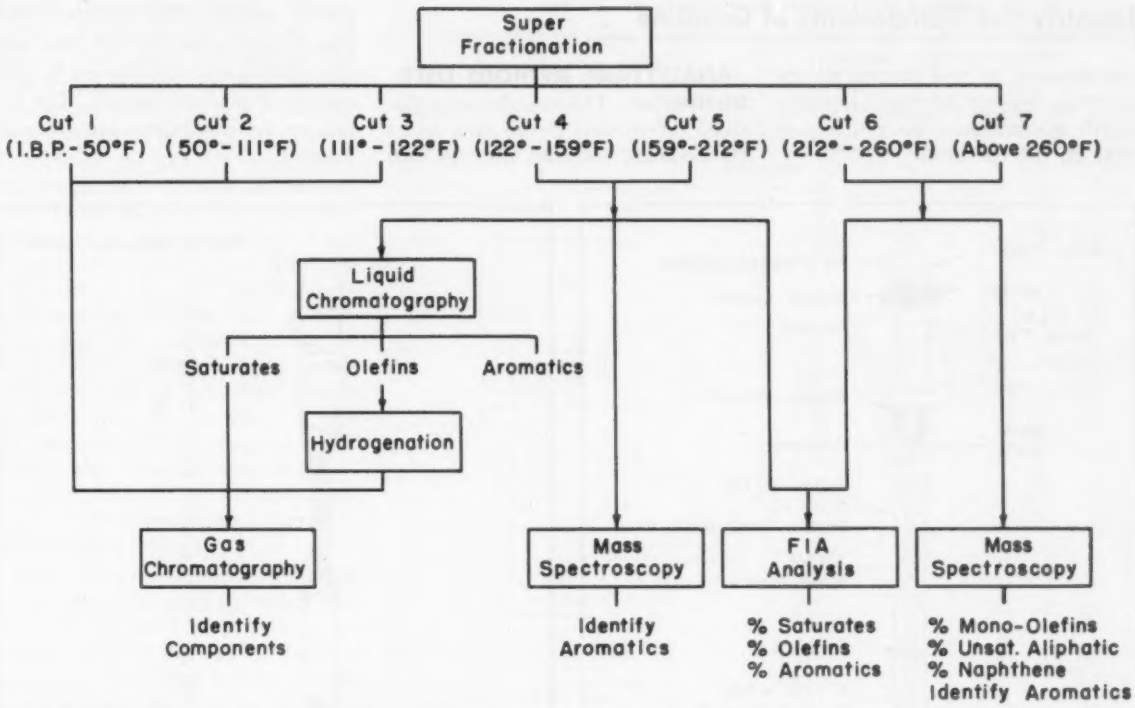

FIGURE 1—Each gasoline sample was processed through a number of steps in order to identify and measure chemical components.

Identify the Components of Gasoline

The identity and amount of chemical components making up olefinic gasolines can now be found by combining several laboratory techniques. Here are results on a few typical samples

J. H. Shively, T. A. Norris and F. M. Roberts
Texaco Research Center
Beacon, N. Y.

MOMENTOUS ADVANCES have been made over the past ten years in the analysis of the gasoline fraction of petroleum. The procedures described in this paper were developed to meet the need for an accurate analytical method applicable to olefinic gasolines.

The gasolines examined were a catalytically cracked gasoline, a thermally cracked gasoline, a gasoline blended to simulate 1940 production and a sample of 1955 production. Figure 1 is an outline of the procedure followed.

The samples were first distilled into six cuts and a residue. Cuts 1, 2 and 3 composed of light ends, C_4s and C_5s were analyzed directly by gas chromatography. Cuts 4 and 5 composed of essentially C_6s and C_7s were separated by liquid chromatography into saturates, olefins and aromatics. The saturates were analyzed directly by gas chromatography. The olefins were hydrogenated and the saturated derivatives obtained were analyzed by gas chromatography. The aromatics were determined by mass spectrometer. Cut 6 composed of C_8s, and the residue were analyzed by mass spectrometer analysis.[2]

The analyses of the gasolines are summarized in Table 1. The accuracy of the over-all analysis varies from cut to cut. In the case of the light ends through C_5s the accuracy of the gas chromatography analysis is the limiting factor. The C_6 and C_7 analysis is limited by the accuracy of the saturate, olefin, aromatic separation. There is no data available to establish the accuracy of the separation method used; however, comparison of the results from liquid chromatography and the fluorescent indicator adsorption (FIA) method shows excellent agreement between the two methods. Probably the accuracy of the liquid chromatography is comparable to FIA accuracy, that is 3 percent for aromatics and olefins and 2 percent for saturates. The average deviation between the two methods for these samples was 3.2 percent for the saturates, 2.4 percent for the olefins and 1.6 percent for the aromatics.

The losses occuring during hydrogenation of the olefins were assumed to be representative of the charge. In any case no significant losses occurred in this step since the largest was less than 1 percent of the sample and probably was distributed over eight different components.

According to Brown's estimate[2] the mass spectrometer type analyses

are accurate to ± 4 percent on the cut basis except for the aromatics which are accurate to ± 0.5 percent on the cut basis.

ANALTYTICAL METHODS USED

Distillation. The samples were distilled on 13 mm by 48 inch super fractionation columns into six cuts and a residue. The columns were run at total reflux for one hour and then distillation was allowed to proceed at 2 percent take-off. The results of the distillations are given in Table 2.

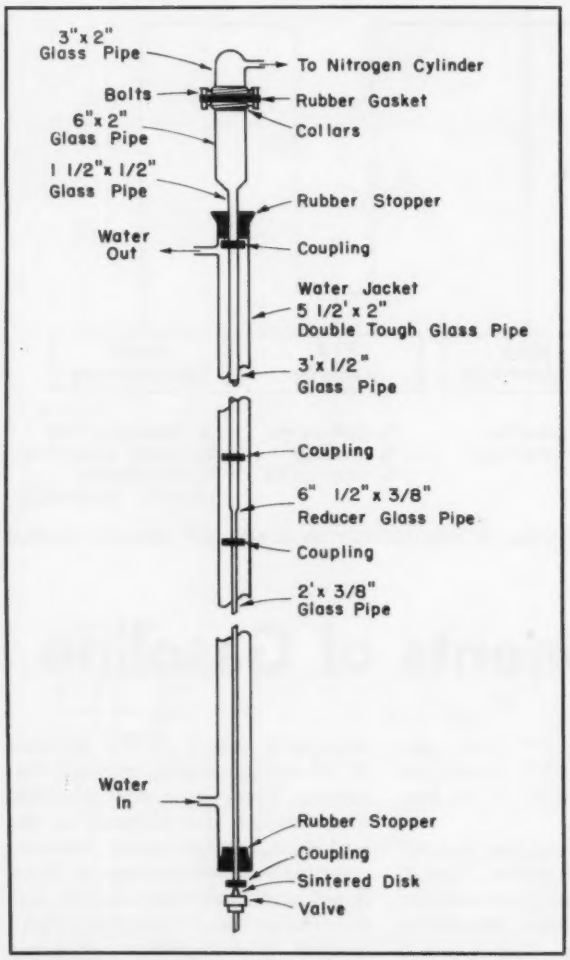

FIGURE 2—Some of the cuts of each sample were separated into saturates, olefins, and aromatics by liquid chromatography.

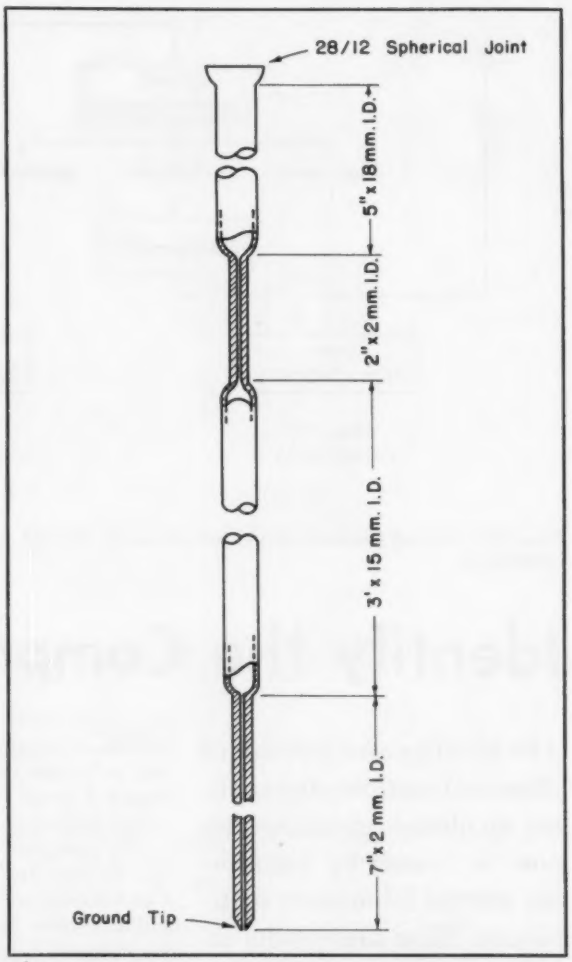

FIGURE 3—A second chromatographic column was used to separate the intermediate cuts.

Recent Advances Used to Develop Analytical Method

A METHOD FOR the analysis of olefinic gasolines is described in the accompanying article. Here is a rundown of the recent advances in the techniques of separation and analysis which helped to formulate the method used.

Glasgow, Willingham and Rossini[7] reported the analysis of the C_6 through C_{10} fraction of a catalytically cracked gasoline. Cady, Marschner and Cropper[8] analyzed virgin, thermal and catalytic naphthas in the C_6 through C_9 range. Considerable lumping of the heavier paraffins was necessary in these analyses and no attempt was made to identify the olefins. Melpolder, Brown, Young and Headington[11] analyzed a naphtha from fluid catalytic cracking in the C_6 through C_9 range.

The development of gas chromatography has done much to speed progress in the field of gasoline analysis. Fredericks and Brooks[9] report a method for the analysis of hydrocarbons through C_5. Eggertsen, Knight and Groennings[5] have described the analysis of C_5 and C_6 saturates by gas chromatography. Lichtenfels, Fleck, Burow and Coggeshall have reported a gas chromatograpic technique for the analysis of the light ends in gasolines.[6] Since completion of the work described in this paper, Eggertsen and Groennings[4] have analyzed the C_6 to C_7 saturates in a reformer charge stock by a gas chromatographic technique employing three separate columns and Knight[6] has reported the analysis of C_5 and C_6 olefins in gasolines.

Liquid Chromatography. Liquid chromatography of the cuts was done in two stages. The sample was first separated into six cuts on the column shown in Figure 2. This column is patterned after the column described by Mair[10] with three major changes: (1) The column was built from special shock-resistant glass pipe in order to minimize the danger of explosion at pressures above 15 to 20 psig. (2) The column and jacket were built as two units and assembled with rubber stoppers. This eliminated the possibility of cracking the seals during packing. (3) The stopcock at the delivery end of the column was replaced with a special valve to eliminate the possibility of contamination from stopcock grease and to reduce the danger of leaks.

The column was packed with 170 to 180 grams of silica gel which was especially prepared to prevent polymerization of olefins during chromatography. The silica gel was added to the column in 30 gram portions. Each time a portion was added, the column was struck with a rubber mallet until no more settling was observed in the gel. The three-inch section directly below the charger section was packed with a mixture of silica gel and 10 to 15¾-inch long pieces of copper wire. The wire serves as a conductor and cools the interior of the column reducing evaporation losses which occurred when the gel heated due to initial wetting. The bottom 2½ inches of the charger section were packed with diatomaceous earth and the column was tapped for an additional 15 minutes to insure even packing.

The column was cooled before charging by circulating water at 35 to 40° F through the jacket for 20 minutes. One drop of FIA dye[1] was added to each 10 cc of sample to be charged. The sample was charged by injecting it below the surface of the diatomaceous earth using a hypodermic syringe. No more than 20 cc of aromatic plus olefin were added to the column per run and the total volume charged never exceeded 40 ml. The volume of aromatic plus olefin in the charge was calculated from FIA analysis. The pressure cap was bolted in place and sufficient nitrogen pressure, 8 to 10 psig, was applied to give a run time

TABLE 1—Summary of the Analysis of Four Gasolines

Carbon No.	Component	LIQUID VOLUME PERCENT			
		Catalytically Cracked (sample 1)	Thermally Cracked (sample 2)	Simulated 1940 Gaso. (sample 3)	Typical 1955 Gaso. (sample 4)
	Saturates				
C_3	propane	....	....	0.06	....
C_4	2-methyl propane	0.10	0.12	0.18	0.09
	n-butane	7.19	6.37	7.42	7.87
C_5	2-methylbutane	4.30	4.05	6.29	3.23
	n-pentane	1.51	4.91	6.21	3.33
	cyclopentane	1.29	2.59	2.87	1.82
C_6	2, 2-dimethylbutane	trace	0.01	0.04	0.03
	2, 3-dimethylbutane	0.21	0.34	0.35	0.24
	2-methylpentane	1.50	2.49	2.94	2.62
	3-methylpentane	0.99	1.77	2.17	1.85
	n-hexane	0.72	3.83	3.56	3.14
	methylcyclopentane	0.23	1.14	2.93	2.61
	cyclohexane	0.08	0.37	1.50	1.04
C_7	2, 2-dimethylpentane	0.01	trace	trace	trace
	2, 4-dimethylpentane	0.09	0.09	0.12	0.18
	1, 1-dimethylcyclopentane / 2-methylhexane / 2, 3-dimethylpentane	0.67	0.61	1.49	1.58
	3-methylhexane / trans-1, 3-dimethylcyclopentane	0.80	1.06	2.72	2.71
	trans-1, 2-dimethylcyclopentane / cis-1, 3-dimethylcyclopentane / ethylpentane	0.41	0.76	3.17	2.32
	cis-1, 2-dimethylcyclopentane	0.05	0.13	0.22	0.01
	methylcyclohexane	0.10	0.47	1.74	0.97
	ethylcyclopentane	0.01	0.11	0.19	0.13
C_8 and heavier	2, 2, 4-trimethylpentane	0.39	1.87	2.18	1.64
	other C_8 paraffins	1.15	4.52	4.72	4.57
	C_8 naphthenes	1.15	2.48	6.58	4.43
	C_9 and heavier paraffins	7.00	9.56	11.08	8.69
	C_9 and heavier naphthenes	4.94	8.58	12.80	9.79
	Olefins				
C_4	1-butene / 2-methylpropene	0.09	0.13	0.16	0.12
	trans-2-butene	0.09	0.06	.....	0.02
	cis-2-butene	0.09	0.08	.....	0.04
C_5	1-pentene	0.69	1.69	0.19	0.48
	2-methylbutene-1	1.98	0.11	.....	0.93
	trans-2-pentene	1.81	0.69	0.10	1.24
	cis-2-pentene	0.78	0.40	0.10	1.24
	2-methylbutene-2	3.79	1.09	.....	1.65
	cyclopentenes[a]	0.10	0.08	0.01	0.08
C_6	2, 2-dimethylbutenes[a]	0.01	.....	trace	...
	2, 3-dimethylbutenes[a]	0.45	0.24	0.02	0.22
	2-methylpentenes[a]	2.63	1.24	0.19	1.34
	3-methylpentenes[a]	2.24	0.86	0.13	0.95
	n-hexenes[a]	2.57	1.43	0.33	1.52
	methylcyclopentenes[a]	1.78	1.15	0.25	1.05
	cyclohexenes[a]	0.13	0.16	0.04	0.09
C_7	2, 2-dimethylpentenes[a]	...	0.04	0.02	0.03
	2, 4-dimethylpentenes[a]	0.23	0.05	0.01	0.10
	1, 1-dimethylcyclopentenes[a] / 2-methylhexenes[a] / 2, 3-dimethylpentenes[a]	1.50	0.59	0.18	0.64
	3-methylhexenes / trans-1, 3-dimethylcyclopentenes[a]	2.60	1.46	0.42	1.19
	trans-1, 2-dimethylcyclopentenes[a] / cis-1, 3-dimethylcyclopentenes[a] / 3-ethylpentenes[a]	0.72	0.26	0.10	0.36
	cis-1, 2-dimethylcyclopentenes[a]	0.21	....	0.02	0.11
	methylcyclohexenes[a]	0.15	0.16	0.06	0.10
	ethylcyclopentenes[a]	0.12	0.09	0.02	0.02
C_8	2, 2-dimethylhexenes[a]	0.09	.....	.....	.....
	2, 2, 4-trimethylpentenes	0.94	1.47	0.45	0.56
	other monoolefins	2.88	2.48	1.15	1.29
	cycloolefins / diolefins / acetylenes	4.21	4.08	0.57	1.57
C_9 and heavier	monoolefins	6.99	6.63	2.77	2.67
	cycloolefins / diolefins / acetylenes	4.11	5.07	2.08	1.67
	Aromatics				
C_6	benzene	0.49	0.25	0.38	0.33
C_7	toluene	0.21	0.86	1.23	2.37
C_8	alkylbenzenes	0.13	0.09	0.10	0.13
	additional aromatics	0.35	0.16	0.07	0.16
C_9 and heavier	aromatics	18.10	9.36	6.23	10.69
Total		98.20	99.94	100.91	99.87

[a] Indicates molecular structure without regard to number or position of double bonds.

of 2 to 2½ hours. The lower end of the column was illuminated with ultraviolet light. Cuts were taken as follows:

- **Saturate**—First drop of effluent until yellow material enters the dead space in the valve.
- **Saturate-Olefin**—Remainder of the colorless material plus the first few drops of deep yellow material.
- **Olefin**—Remainder of yellow material until blue material enters dead space.
- **Olefin-Aromatic**—Remainder of yellow material plus the first few drops of deep blue material.
- **Aromatic**—Remainder of blue material until brownish red material enters dead space.
- **Aromatic-Alcohol**—Remainder of blue material and all of brownish red material.

In the second stage of chromatography the intermediate (saturate-olefin, olefin-aromatic and aromatic-alcohol) cuts were separated on a second column (Figure 3).

The second or fine separation column was packed with the silica gel using a massage type vibrator. The column was illuminated with ultra violet light. Maximum charge for a saturate-olefin cut was 7 ml, for an olefin-aromatic or aromatic-alcohol cut 5 ml. The cuts were collected as follows:

- **Saturate-Olefin**—The saturate was colorless, the olefin yellow.
- **Olefin-Aromatic**—The olefin was yellow the aromatic blue.
- **Aromatic-Alcohol**—The blue aromatic material was the only portion collected.

The run time for these separations was about two hours. The results are given in Table 3.

Hydrogenation of Olefins. The two main pitfalls to be avoided in the hydrogenation step were cracking and isomerization. Several runs were made on hexylene-1 until proper conditions for maximum hydrogenation and minimum cracking and isomerization were achieved. The products of the hexylene-1 hydrogenation were analyzed by gas chromatography and proper operating conditions were established in this way.

The olefins obtained from liquid chromatography were charged to a 50 cc "stirred" reactor together with 2 grams of platinum asbestos catalyst. The reactor was pressured to 300 psig with hydrogen and the reaction was allowed to proceed without added heat. The reactor was repressured to 300 psig whenever the pressure dropped to the region of 100 psig. When the reaction rate began to fall off the reactor was heated to 250° to 350° F until the sample stopped taking up hydrogen. The reactor was cooled and the hydrogenate was distilled under vacuum into a trap immersed in liquid nitrogen. The last traces of hydrogenate were removed from the reactor by flushing with hydrogen.

Gas Chromatography. The saturate fractions and hydrogenated olefins were analyzed by gas chromatography. In all cases the flow rate was 100 ml/min., measured at the column exit, and the column temperature 30° C. The light ends through C_4 were all run on a 4-meter column of 30 grams dibutylformamide supported on 100 grams 40/60 mesh firebrick. The C_5s were determined on a 5-meter column of 35 grams diethyl n-butylmalonate on 100 grams 40/60 mesh firebrick. The C_6 saturates and one of the hydrogenated C_6 olefin cuts were run on 4 meters of 5 grams tetraisobutylene on 100 grams firebrick followed by 2 meters of 5 grams of a silicone fluid (dimethyl polysiloxanes—3.0 centistokes at 25° C) on 100 grams of firebrick. The remaining three hydrogenated C_6 olefin cuts and the C_7 saturates and hydrogenated olefins were run on 6 meters of 3 grams of a naphthene base oil with a Saybolt Universal viscosity of 55 seconds at 100° F on 100 grams firebrick.

The analyses which were made with the dibutylformamide and tetraisobutylene-silicone columns could have been done equally well with the diethyl-n-butylmalonate and the naphthene base oil columns respectively. The latter columns were developed after this work had started. Their main advantage is that the column ingredients are easier to obtain.

The gas chromatographic columns used were calibrated with pure hydrocarbons and the hydrocarbon components were identified from their observed retention times.

The results of the gas chromatographic analyses are given in Tables 4 and 5.

Mass Spectrometer Analysis. The C_6 and C_7 cuts were analyzed by mass spectrometer to give a breakdown on the aromatics present. The C_8 cuts and the residues were analyzed solely by mass spectrometer.

The method of analysis used for the C_8 cuts and the residues was described by Brown.[2] In addition to the type analysis on these cuts a cal-

TABLE 2—Fractional Distillation

Cut No.	Boiling Range, °F	Carbon No.	VOLUME PERCENT OF CHARGED GASOLINE SAMPLE			
			Catalytically Cracked (Sample 1)	Thermally Cracked (Sample 2)	Simulated 1940 Gasoline (Sample 3)	1955 Gasoline (Sample 4)
1	up to 50	light ends	7.7	5.6	7.3	8.3
2	50 to 111	C_5	15.4	15.2	13.6	13.1
3	111 to 122	C_5	0.7	0.7	0.6	0.9
4	122 to 159	C_6	12.2	13.7	13.6	14.4
5	159 to 212	C_7	11.4	11.2	16.0	15.6
6	212 to 260	C_8	11.5	14.6	14.3	14.3
Residue	above 260	C_9 and heavier	41.1	39.0	34.6	33.4
Total			100.0	100.0	100.0	100.0

TABLE 3—Liquid Chromatography of C_6 and C_7 Cuts

Cut No.	Boiling Range, °F	Compound Type	LIQUID VOLUME PERCENT			
			Catalytically Cracked (Sample 1)	Thermally Cracked (Sample 2)	Simulated 1940 Gasoline (Sample 3)	1955 Gasoline (Sample 4)
4	122—159	Saturates	32	68	88	57
		Olefins	67	31	9	38
		Aromatics	1	1	3	5
5	159—212	Saturates	21	51	90	70
		Olefins	70	47	7	26
		Aromatics	9	2	3	4

About the Authors

Shively

Norris

Roberts

J. H. Shively is group leader of the Analytical Department for the Texaco Research Center, a position he has held since 1944. Holder of a B.S. degree from Mount Union College and a M.S. degree from Ohio State University, he has been with Texaco, Inc. as an analytical chemist since 1940. He is a member of ACS and the Research Society of America.

T. A. Norris is project chemist for Texaco Research Center's Analytical Department, Beacon, N. Y. He holds B.S. and M.S. degrees from Holy Cross College and is a member of ACS. He joined Texaco, Inc. in 1951 as an analytical chemist, working with analysis of gaseous hydrocarbons, gasoline, and lube oils. He became project chemist in 1959.

F. M. Roberts is supervisor of the Analytical Department for the Texaco Research Center. He received a B. Ed. degree from Southern Illinois University and a M.S. degree from Georgia Institute of Technology. Roberts became head of the Analytical Department in 1955, having worked in all phases of petroleum analysis for Texaco, Inc. since 1941.

culation of individual aromatics was made.

The results obtained are given in Table 6.

TABLE 4—Gas Chromatographic Analysis of Cuts 1, 2 and 3 and the Saturates From Cuts 4 and 5

Component	LIQUID VOLUME PERCENT			
	Sample 1	Sample 2	Sample 3	Sample 4
propane	....	....	0.2	....
2-methylpropane	0.3	0.3	0.4	0.2
n-butane	23.9	17.4	15.1	21.0
1-butene 2-methylpropene	0.3	0.3	0.4	0.5
trans-2-butene	0.3	0.3	....	trace
cis-2-butene	0.3	0.3	....	trace
2-methylbutane	14.3	11.2	11.6	7.5
n-pentane	5.0	13.9	12.4	8.3
1-pentene	2.3	3.0	0.4	1.4
2-methylbutene-1	6.6	0.3	....	2.3
trans-2-pentene	6.0	1.9	0.2	3.0
cis-2-pentene	2.6	1.1	0.2	3.0
2-methylbutene-2	12.6	3.0	....	4.0
cyclopentane	4.3	7.1	6.0	4.9
2, 2-dimethylbutane	trace	trace	trace	trace
2, 3-dimethylbutane	0.7	0.8	0.8	0.5
2-methylpentane	5.0	6.9	6.4	5.1
3-methylpentane	3.3	4.9	4.8	3.7
n-hexane	2.7	10.4	7.9	6.3
methylcyclopentane	2.3	3.0	6.2	5.4
cyclohexane	0.3	1.1	3.1	2.3
2, 2-dimethylpentane	trace	trace	trace	trace
2, 4-dimethylpentane	0.3	trace	0.2	0.5
1, 1-dimethylcyclopentane 2-methylhexane 2, 3-dimethylpentane	2.0	1.6	3.1	3.5
3-methylhexane trans-1, 3-dimethylcyclopentane	2.3	2.7	5.6	5.9
trans-1, 2-dimethylcyclopentane cis-1, 3-dimethylcyclopentane 3-ethylpentane	1.0	1.9	6.4	4.9
cis-1, 2-dimethylcyclopentane	trace	0.3	0.4	trace
methylcyclohexane	0.3	1.1	3.5	2.1
ethylcyclopentane	trace	0.3	0.4	0.2
2, 2, 4-trimethylpentane	1.0	4.9	4.3	3.5
Total	100.0	100.0	100.0	42.7

TABLE 5—Gas Chromatographic Analysis of Hydrogenated Olefins From Cuts 4 and 5

Component	LIQUID VOLUME PERCENT			
	Sample 1	Sample 2	Sample 3	Sample 4
n-butane	....	....	trace	....
2-methylbutane	0.9	0.6	trace	0.8
n-pentane	0.2	0.4	trace	0.5
cyclopentane	0.6	0.7	0.4	0.9
2, 2-dimethylbutane	0.1	....	trace	....
2, 3-dimethylbutane	2.7	2.4	0.9	3.2
2-methylpentane	15.7	12.3	10.0	16.4
3-methylpentane	13.3	8.6	6.6	11.5
n-hexane	15.4	14.3	16.7	18.5
methylcyclopentane	10.6	12.0	12.2	12.4
cyclohexane	0.8	1.8	1.7	1.0
2, 2-dimethylpentane	....	0.5	1.3	0.4
2, 4-dimethylpentane	1.4	0.5	0.8	1.1
1, 1-dimethylcyclopentane 2-methylhexane 2, 3-dimethylpentane	9.0	6.7	7.4	7.2
3-methylhexane trans-1, 3-dimethylcyclopentane	15.8	16.7	16.2	13.4
trans-1, 2-dimethylcyclopentane cis-1, 3- dimethylcyclopentane 3-ethylpentane	4.3	3.0	3.4	4.0
cis-1, 2-dimethylcyclopentane	1.3	....	0.9	1.2
methylcyclohexane	0.9	1.8	2.2	1.1
ethylcyclopentane	0.7	1.0	0.9	0.2
2, 2, 4-trimethylpentane	5.7	16.7	18.4	6.2
2, 2-dimethylhexane	0.6	....	....	....
Total	100.0	100.0	100.0	100.0

TABLE 6—Mass Spectrometer Analysis of Cuts 4, 5, 6 and the Residue

Component	LIQUID VOLUME PERCENT			
	Sample 1	Sample 2	Sample 3	Sample 4
paraffins	16	32	39	32
naphthenes	11	19	40	30
monoolefins	29	20	7	12
cycloolefins diolefins acetylenes	17	15	4	8
benzene	0.8	0.3	0.7	0.8
toluene	2.4	1.0	1.6	3.0
C^8 alkylbenzenes	0.2	0.1	0.1	0.2
additional C^8 aromatics	0.5	0.2	0.1	0.2
C^9 and heavier aromatics	24	12	8	14
Total	100.9	99.6	100.5	100.2

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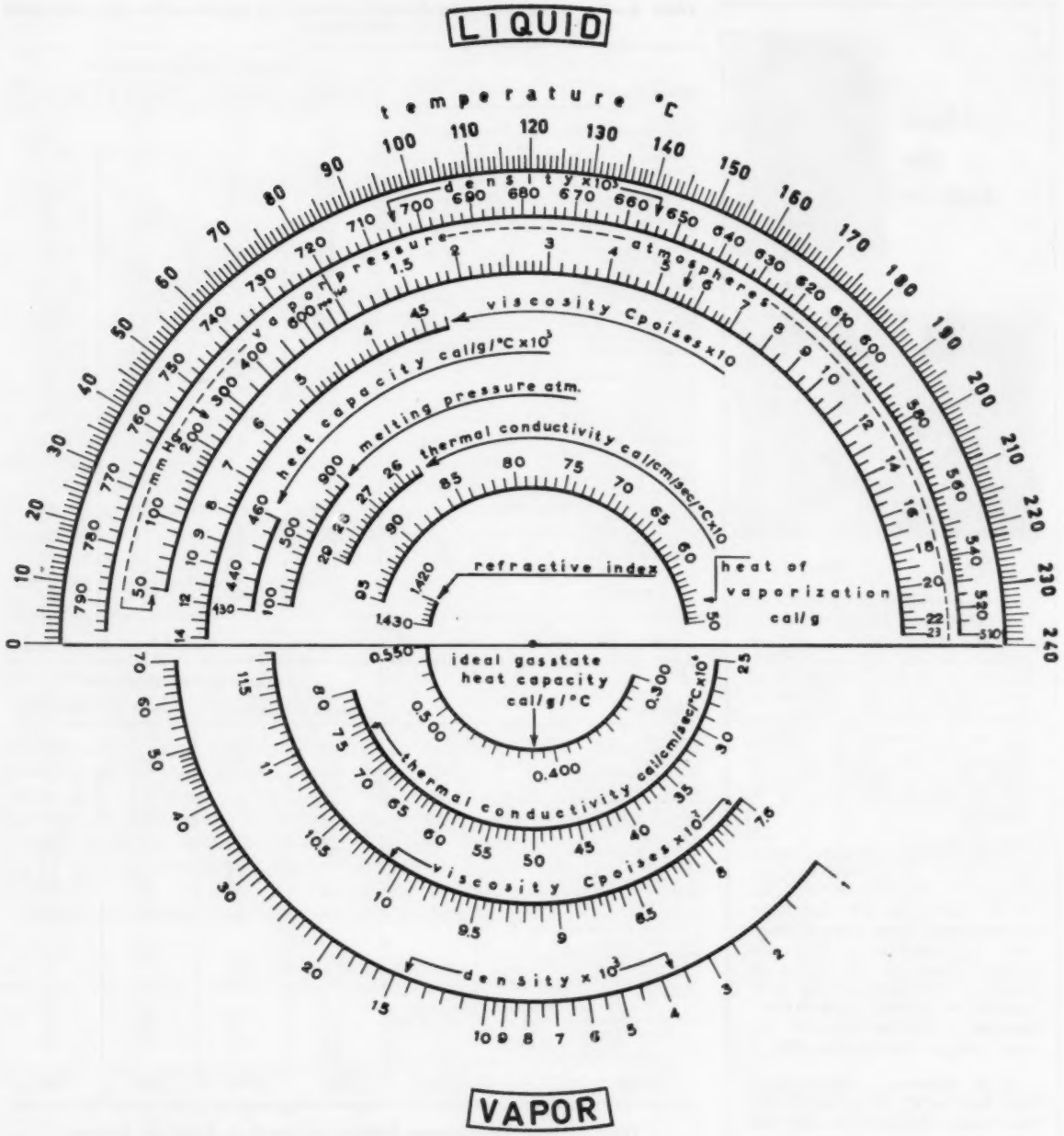


Find Cyclohexane Properties by Nomogram

A. M. P. Tans
Staatsmijnen in Limberg, Geleen, Netherlands

THIS NOMOGRAM gives the physical properties of cyclohexane. It has been constructed from literature values. The use of the nomogram is as follows: Any line passing through the center intersects the scales in corresponding points. The scale labeled "melting pressure" is to indicate the influence of pressure on the melting point, e.g. it can be read off that at a pressure of 600 atm. the melting point of cyclohexane amounts to 38.5° C. ##

PM—Key to Equipment Failure Control

Preventive maintenance does not prevent equipment failures, but insures you that they will not occur at an uneconomical rate

J. F. Thornton, Phillips Petroleum Co.
Bartlesville, Okla.

THERE ARE PROBABLY as many different Preventive Maintenance systems as there are maintenance supervisors. These systems vary from some which merely give lip service to the PM philosophy to some completely integrated formal systems, and in a good many of them, the term PM is nothing but a gimmick for making more work.

Of course, making more work instead of reducing it is not always bad. Often it takes more work and more cost to make more profit. And after all, maximum profit, not less work, is the primary objective. The point is that in a profit-making organization, PM must contribute to the profit objective of the enterprise. Without economics based on recorded maintenance and failure costs, a PM system can easily become a fancy set of procedures for doing unnecessary work.

Preventive Maintenance provides the framework for all maintenance activities and is applied to support the objective by insuring that facilities are in a condition to produce a quality product at the lowest possible unit cost. This is not necessarily the lowest possible total maintenance cost but is the maintenance cost which keeps the product cost at a minimum.

It is the task of Preventive Maintenance through planned, scheduled inspection, maintenace and overhaul to insure that equipment failures do not occur at an uneconomic rate. This concept of Preventive Maintenance stems from three factors:

- That day-to-day repairs are required to keep facilities in safe and efficient operating condition.
- That repairs will fall into a repetitive pattern.
- That these repairs can be analyzed and a prediction made of what to do to prevent those which economically justify prevention.

Since no large scale prediction is perfect, and complete prevention is usually more costly than occasional failure, day-to-day repairs will always be required. Therefore, the basic relationship between the two practices is that the number and the cost of repairs is a measure of the effectiveness of Preventive Maintenance activity.

The guiding principle of PM is that planned, periodic application of the correct maintenance service within systematic procedure will result in optimum equipment service and life. The approach to this economic optimum is controlled by Preventive Maintenance and the desired result is:

- A reduction in the total cost of maintenance.
- Increased production and fewer interruptions to operations due to equipment break-downs and repairs.
- A level workload and a stabilized work force.
- A predetermined requirement for and a reduced inventory of materials and spare parts.

Basic Definitions. Preventive Maintenance is systematic attention and analysis applied in economic amounts to insure proper functioning and to retard the rate of deterioration of physical facilities. Preventive Maintenance activity includes:

Operating Maintenance. Properly operating, caring for, cleaning, and in specified cases, lubricating equipment. This may also include making small adjustments and correcting minor defects during the course of operations. This Preventive Maintenance will usually be done while equipment is operating.

Shutdown Maintenance. This intermediate segment of Preventive Maintenance work includes examining, checking, testing, partially dismantling, replacing consumables, lubricating, cleaning or other work short of overhaul or renovation. This Preventive Maintenance requires that equipment be shut down to accomplish the inspection or repair.

PM Overhaul. Dismantling and examining equipment before breakdown occurs and replacing or renewing components which have reached close to a theoretical maximum service limit. This Preventive Maintenance requires that equipment be shut down for longer periods of time to accomplish inspection or repair. The importance of scheduling overhaul, when possible, during times when equipment is idle for other reasons is obvious.

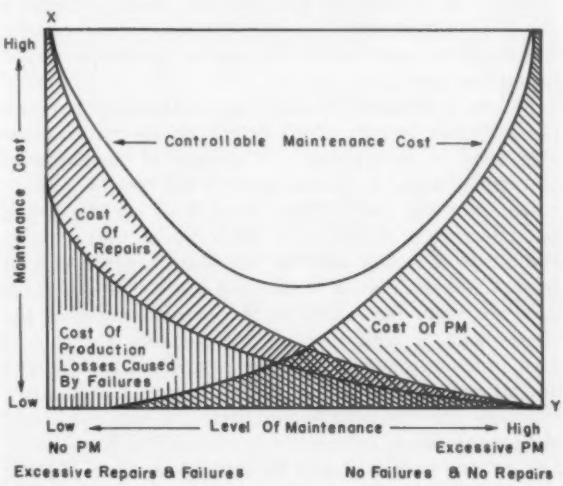
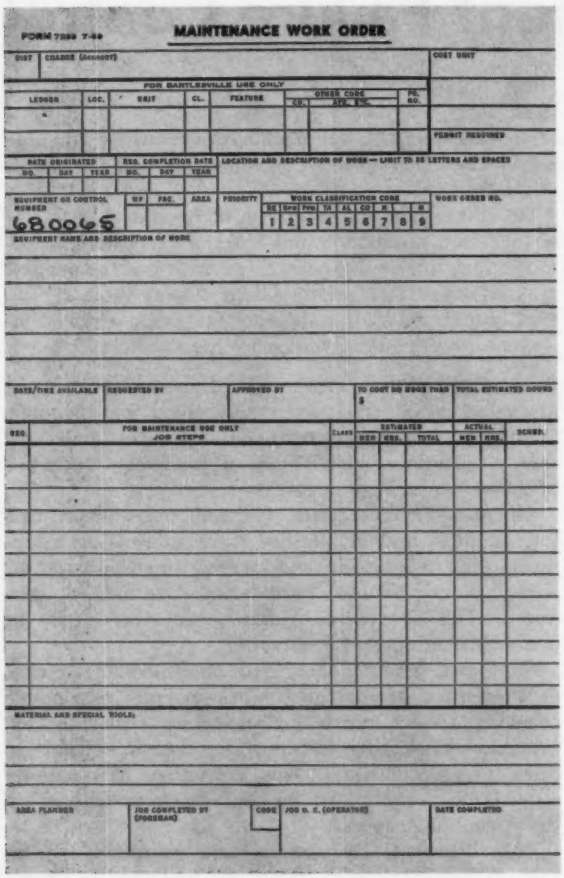


FIGURE 1—The "level of maintenance" determines optimum production at the lowest costs.



FORM 7289 7-69

MAINTENANCE WORK ORDER

DIST | CHARGE (Account) | COST UNIT

FOR BARTLESVILLE USE ONLY

LEDGER	LOC.	UNIT	CL.	FEATURE	OTHER CODE CO.	OTHER CODE ADD. NO.	PO. NO.

PERMIT REQUIRED

DATE ORIGINATED MO.	DAY	YEAR	REQ. COMPLETION DATE MO.	DAY	YEAR	LOCATION AND DESCRIPTION OF WORK — LIMIT TO 30 LETTERS AND SPACES

EQUIPMENT OR CONTROL NUMBER	WP	FAC.	AREA	PRIORITY	WORK CLASSIFICATION CODE (ME Grad Proj TA AL GO T R M)	WORK ORDER NO.
680065					1 2 3 4 5 6 7 8 9	

EQUIPMENT NAME AND DESCRIPTION OF WORK

DATE/TIME AVAILABLE	REQUESTED BY	APPROVED BY	TO COST NO MORE THAN $	TOTAL ESTIMATED HOURS

SEQ.	FOR MAINTENANCE USE ONLY JOB STEPS	CLASS	ESTIMATED MEN	ESTIMATED HRS.	ESTIMATED TOTAL	ACTUAL MEN	ACTUAL HRS.	SCHED.

MATERIAL AND SPECIAL TOOLS:

AREA PLANNER	JOB COMPLETED BY (FOREMAN)	CODE	JOB O. K. (OPERATOR)	DATE COMPLETED

FIGURE 2—The work order is the basic record of a maintenance job.

Level of Maintenance. How well can you afford to maintain a piece of equipment? The level of maintenance is set by the nature, the quantity and the frequency of application of the above phases of PM. The purpose of Preventive Maintenance is to achieve a "level of maintenance" on all facilities which enables the optimum production of quality products at the lowest unit cost.

Figure 1 attempts to show the relationship between the economic factors which determine the most profitable level of maintenance. The level of maintenance (horizontal axis) is plotted against the cost of maintenance (vertical axis). There is no scale on this chart, but referring to the extreme left it is seen that with no PM (that is, a low level of maintenance) the cost of repairs and the cost of production losses caused by failures are high. Now look at the extreme right of the chart—with a high level of maintenance we can at least imagine a situation of no repairs and no failures but an excessive PM cost. We'll all agree that the two extremes are undesirable and that the optimum level of maintenance is somewhere in the middle. But where? Let us now coin a phrase by adding together (1) the cost of PM, (2) the cost of repairs, and (3) the cost of production losses and calling it the controllable maintenance cost. This is plotted at the top of Figure 1. The desired level is, of course, that level where the controllable maintenance cost is the least.

Now, notice that the chart plots the cost of repairs as an addition to the cost of failures so that the line XY represents the sum of these two costs. Then we see that the controllable maintenance cost is least where XY cross the Cost of PM line. This says that the controllable maintenance cost is the least when PM cost equals the sum of the cost of repairs and the cost of failures.

But look how nice and flat the controllable maintenance cost curve is through the middle range. This is most convenient because we can now know that we are in the economic range when PM cost approximates the sum of the cost of repairs and the cost of failures. Since PM is not an exact science, this approximation is most important.

Records. The primary purpose of the records kept in connection with PM is to permit the research and analysis necessary to arrive at the optimum "level of maintenance" based upon production economics, factual cost data and equipment repair and performance history. The results of this research and analysis provide factual data to use in making adjustments in the type and frequency of PM service provided. The research further supplies facts, not just opinion, to guide those people responsible for equipment selection and use of materials. Cost and economics dominate a good PM program and dictate what should be done. Proper cost reporting and analysis will supply the facts on which "level of maintenance" decisions are based. Costs will also determine what types of equipment can profitably be included in the Preventive Maintenance program. Exclusion of some types of equipment from the Preventive Maintenance program, poor maintenance, and even no maintenance, are economically justified in many instances.

Factors Influencing Level of PM. The decision to include or exclude any item or group of equipment in the PM program can only be made after specific analysis of the equipment. The question to be answered in making the decision—"Is it necessary and is it worth the cost?"—and all of the following factors, need to be evaluated.

- If the item of equipment is critical to operations and failure will cause loss of production, costly damage to equipment or harm to an employee, then the level of PM should be high enough to prevent failure.
- If the cost of downtime and the cost of repairs exceed the cost of PM, then more PM is probably justified.
- If the cost of PM would exceed the replacement costs, in non-critical equipment, the equipment should be excluded from the program and be replaced upon failure.
- If the normal life of the equipment without PM exceeds operating needs and the salvage value of the equipment is nominal at the end of the operating period, the equipment should be excluded.
- If standby equipment or unused capacity is available in case of failure, the need for the level of PM is contingent on factors such as potential damage to other equipment and cost of breakdown maintenance.

In evaluating equipment for PM coverage and level

EQUIPMENT DATA SHEET — Class Name: PUMPS, CENTRIFUGAL — Equip. No. 680065

Location (Dist.-Plant-Unit): Rice - NG & Treater — Equip. Operating Name: Catalyst mix pump — AFE Item No.: G-5756-28-1

Manufacturer: Goulds — Model/Fig/Type: 3405 M — Size: 6x8x12 — Serial No.: 287A643

Reference Drawing — Catalog — Bulletin — Manual — Date Last Reviewed

OPERATING DATA

Field: Catalyst — Pump Temp °F — Curve No. — Orig. HP&R: 13 — Orig. Cooling: Yes — Normal HP

GPM: 100 — Sp. Gr. @ °F — Orig. H. P.: 250 — Quench Oiled: Yes — Curve End HP

Feet: 1600 — Sp. Gr. @ P. T. — Max. H. P.: 250 — Ext. Finish: NO — Driver Serial #: 300052

RPM: 1780 — BOT Facing CPIG — Hydro Test P. S.: 315 — Kit S — Driver HP: 50

MAINTENANCE AND TECHNICAL DATA

VERTICAL: | HORIZONTAL: X | LUBRICANT: Guerara

BEARINGS: TYPE/MFG./NO. — Radial: MRC - 307-S — Thrust: MRC - 7307 — Duplex Brg. Mounting — Direction of Thrust Outboard | Inboard | Both

CASING GASKET THICKNESS: 1/64"

CLEARANCES, ADJUSTMENTS & TOLERANCES:

BEARINGS: MAIN — Column — Rotor — Center — Top — S. Box Bush — Intermediate — Bottom

Bearing Bracket-Stuff Box Alignment — Shaft to Coupling (0.0005" Max.) — Shaft End Play — Shaft-Stuff. Box Alignment — Bracing Ring

COUPLING: GUARD: YES X NO ☐ — Size: B — Wts.: F&R — Type: F — Spacer: DA — Bore: 1 3/8 - 1 3/8 — Keyway: 3/8 - 3/8

FLANGE OR CONNECTIONS:

	SIZE	RATING	FACING
Suction	8"	125 AS	RF
Discharge	6"	125 AS	RF

IMPELLERS: MAX. 12" — MIN. 8 1/4" — Stages: 1 — Size: 9 3/16" — Pattern: 62134 Dwg 238-8 — Type: Closed - Double Suction

MECHANICAL SEAL: DA

SIZE	MFG.	TYPE	CODE	DRG. NO.

SHAFT DIAMETERS AT:

Impeller	Coupling	Stuff. Box	Bearings
1 9/16"	1 3/8"	1 7/16"	

SHAFT: Extension — Overall Length: 20 1/8" — Max. Run-Out

STUFFING BOX PACKING:

MFG	TYPE	SIZE	NO. REQ.	SYMBOLS
Garlock	734	3/8 x 3/8	5	A

(Sequence — Left to gland end, L to lantern ring)

Outboard: AAALAA — Inboard: AAALAA

Stuffing Box depth: 1 3/4" — I.D.: 2 1/2" — O.D.: 2 7/16" Deep — Lantern Ring Width: 3/4" — c/l of Lantern Ring to Stuff Box Face: 15/16"

Form 7010 3-56

FIGURE 3—Equipment data sheets set up basic information on each equipment item.

of maintenance, a high degree of judgment must be exercised in calculating the risks, potential hazards and weight given to each of the above factors.

Prerequisites To Formal PM

A working system of written work orders with effective planning and scheduling is a prerequisite to effective PM. Figure 2 is a copy of a work order form which is not unusual but which is an integral part of the PM system and is worth the time to review briefly.

The Work Order is the basic record of a maintenance job from the time it is initiated by the originator until the job is completed satisfactorily and closed by the maintenance forces. It describes the work to be done, its location, the specific equipment name and number, when the work must be done, and who requested the work or who has any additional information needed. It serves as the basis for justification and approval of the work. It lists the manpower, material, equipment and special tools needed for the job. It provides the maintenance foreman and his men with all pertinent information concerning the job. On completion of the work, it becomes a part of the repair history of the equipment worked on. The work order transfers accurate job information from the man who wants the work done to the man who analyzes the job's requirements and on to the men who are to do the work.

Phillips' concept of work order authorization is that only operating personnel, as custodians of the equipment and responsible for its performance, can authorize maintenance work orders. As you will see later, PM Engineers (and other staff service people) because of their special knowledge and experience "originate" work orders. However, we adhere to the concept that the work order form is considered a recommendation or a work request until authorized by the signature of the proper operating supervisor. Thus the position of PM Engineer carries no direct organizational authority. Actually, our experience shows that his technical knowledge and his factual maintenance record and cost on each piece of equipment gives him practically unlimited authority. Operating personnel are quick to see the advantages, welcome the intrusion and invariably approve the recommended PM work.

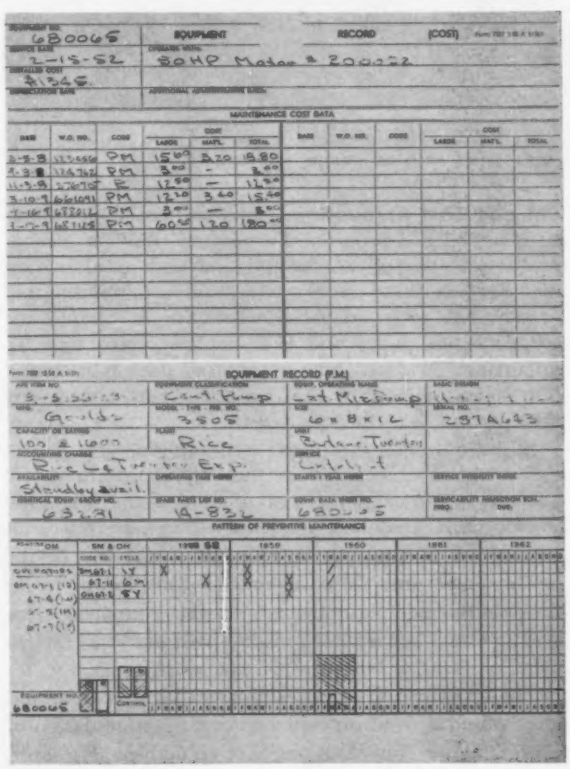
The placing of PM equipment identification number in the block titled "Equipment or Control Number" on the work order will permit the reporting of the work order number, date, man-hours and total cost by equipment number, thus providing cost data for the Preventive Maintenance program.

Equipment Identification. A system of equipment identification is essential to orderly and uniform PM. We use a six digit number for each piece of equipment.

The first two digits identify the class of equipment. For this purpose we use numbers identical to the Company Warehouse Catalog Category Numbers. Thus the first two digits of the Equipment Identification Number for any piece of equipment correspond to the first two digits of the Catalog Number for all repair parts.

The last four digits are simply a departmental serial number. They are for identification only and have no other significance such as to type, location or service, which information is included on equipment records.

This six digit number is stamped on metal tags affixed to each piece of equipment.



EQUIPMENT RECORD (COST) — Equipment No. 680065 — Service Date: 3-15-52 — Installed Cost: $1345 — Operating Name: 50HP Motor & 2 Gear

MAINTENANCE COST DATA

DATE	W.O. NO.	CODE	LABOR	MATL.	TOTAL
2-5-8	113-656	PM	15.00	4.20	19.20
1-13-8	114-742	PM	3.00	-	3.00
1-5-9	276795	E	12.00	—	12.00
3-10-9	661691	PM	12.00	3.60	15.60
7-16-9	677811	PM	3.00	—	3.00
1-7-9	685145	PM	60.00	1.20	180.00

EQUIPMENT RECORD (P.M.) — Equipment No. 680065 — Equipment Classification: Centrifugal Pump — Equipment Operating Name: 2nd Mix Pump — Manufacturer: Goulds — Model — Type — Size: 6 x 8 x 12 — Serial No.: 287A643 — Capacity or Rating: 100 & 1600 — Plant: Rice — Unit: Reforming Treating — Accounting Charge: P. & M. Treating Exp. — Service: Catalyst — Department: Standby avail. — Operating Time Meter — Starts 1 Year Meter — Service Interval Meter — Historical Group — Group No.: 63.31 — Spare Parts List No.: 1A-832 — Equip. Data Sheet No.: 680065 — Maintainability Inspection Req. — Due

PATTERN OF PREVENTIVE MAINTENANCE

Activity	Shop & Dept.	Code No.	Cycle	1958 4Q	1959	1960	1961	1962
Oil Pumps	Shop 1	67-16	1Y	X	X	X	X	/
Oil Gears (2)	Shop 1	67-16	6M					
67-8 (1st)	Shop 1	67-16	3Y					
67-8 (1st)								
67-7 (1st)								

Equipment No. 680065

FIGURE 4—Labor costs are shown here as dollar values. Manhours may be better for future comparisons.

IDENTICAL EQUIPMENT GROUPS

Class 68

I. E. Group No.	Model/Type/Fig. No.	Sizes
68051	3029	All
68101	3047F	All
68121	3065, 3075, 3085 & 3095	All
68141	3157 & 3158	All
68161	3169	All
68181	3305S	1½x2-9,2x3-9,2x3-90
68191	3305M	2x3-11,3x4-11, 3x4-110,4x6-11 & 4x6-110
68201	3325 & 3345	All
68221	3330	All
68241	3360 - 3362	All
68251	3380	All
68261	3390	All
68271	3405S	3x4-80,3x4-8, 3x4-8E,3x4-12, 3x4-14,4x6-8, 4x6-80,4x6-12 & 4x6-120
68281	3405M	3x4-17,4x6-14, 4x6-17,4x6-170,6x8-8, 6x8-80,6x8-12, 6x8-120,6x8-14, 6x8-140,6x8-17, 6x8-170,8x10-12 & 8x10-120
68291	3405L	8x10-14,8x10-140, 8x10-17,8x10-170, 10x12-12,10x12-14, 10x12-140,10x12-17, 10x12-170,12x14-14
68301	3450	All
68311	3460	All
68321	3470 & 3472	All
68331	3475	All

FIGURE 5—The inventory is grouped into similar equipment types such as pumps shown here.

PM and Cost Accounting. Costs and economics dominate a good PM program. Fortunately, Phillips' mechanization of payroll accounting and cost accumulation includes furnishing the timely cost information required in our PM program. Cost accounting is beyond the scope of this paper and it is not important that we understand in detail how accounting data is prepared but is most important that we understand how to use the data that is forthcoming.

In general, the mechanized accounting procedure uses the work order concept in that all expenditures are charged to work orders for accumulation and, when the work order is complete, are "cleared" to the proper cost center. An added refinement is the capability of the system to accumulate maintenance expenditures to individual pieces of equipment when the equipment identification number is shown in the space marked "Equipment or Control Number" on the work order.

The combination of the equipment identification and mechanized accounting will *permit* the accumulation of charges by *all* individual pieces of equipment. However, this does not mean that such accumulation should be accomplished on all individual pieces. The extent of this accounting refinement is dependent upon economics and is determined by the judgment and experience of the administrators of the PM program.

Establishing The PM Program. The first step Phillips took in establishing a formal PM program was the completion of a PM manual. This paper is more or less a condensed version of the manual. The success of any program depends on wide distribution and understanding of the why and how of its application. Successful PM or anything else is not just learning some rules and procedures. The principles and "reason why" behind the procedures must be understood by all people concerned.

We don't like the phrase "sell the program." This implies that whoever is buying it may not be getting a bargain. Rather we saw that knowledge of the principles, procedures and results would do most to insure success. Thus the first step was really a training situation with the manual as a text and the whole plant the student body. A systematic approach to the actual installation of PM is essential because of the volume of items of equipment to be covered. We chose to build the program in pieces rather than attempting to cover an entire plant or group of plants at one time. Using this approach, the program is developed for each class of equipment through the following steps:

Example—Centrifugal Pumps.

A. Establish an inventory of basic equipment information and identify each item of equipment with a single numbering system for all assets and set up permanent records. (See Figures 3 and 4)

B. Sort the inventory into groups of nominally identical equipment. (See Figures 5 and 6.) Centrifugal pumps of each manufacturer, for example, have been placed into nominally identical groups. Each group contains those pumps which have similar construction and maintenance procedures. All of the pumps in a particular identical group are not truly identical as they may vary in size, materials, or special features such as sleeve construction, special clearances, mechanical seals, etc. Pumps within a certain identical group may also have been designed to meet special design features such as case maximum working pressure, high suction pressure, special flanges, and others.

C. Prepare and code standard work descriptions of PM service to be applied to each group. (See Figure 7.)

D. Determine the frequency and timing of application of PM service to each piece of equipment. (Figure 4) Initially without recorded experience these are determined by the good judgment of the PM Engineer and the particular Plant Maintenance Foreman involved.

E. Secure operations approval and arrange for work scheduling. This may be done by means of quarterly or annual summaries in which advance blanket approval is made or may be done on individual work order basis.

F. Accumulate maintenance and cost records. (Figure 4) At present this information is manually posted on the equipment record card from data processing machine runs. However, in the largest plant a system of filing a card, on which the information is both punched and printed, is being set up.

Responsibilities. The success of the PM program demands that all the skill and knowledge available be

brought to bear on maintenance problems. The duties and responsibilities of many groups and individuals influence the results and it is important that each understand his responsibilities in the program. These general responsibilities are outlined in the following paragraphs.

Management must formulate the plan, arrange to guide its installation and evaluate the results of PM activity. Specifically, Management is responsible for:

- Endorsing the philosophy of Preventive Maintenance and creating the climate which encourages Preventive Maintenance as a means to achieve low maintenance unit cost. The attitude of management is important in the problem of the priority of PM relative to normal repair work.
- Providing the personnel and facilities required.
- Maintaining the correct organization balance between the custodians of the facilities (operators) and the maintenance groups responsible for the installation and administration of the program.
- Providing accurate, adequate and timely cost data on the program itself, the cost of repairs and the cost of failures to insure factual analysis and measurement of results.
- Evaluating performance and results periodically through established routine.
- Insuring interchange of data between organization components with similar facilities and equipment.

Operations. Plant operating organizations have been given custody of the company's assets and are fully accountable for the safe and economic operations of the facilities. Thus the responsibilities of the operating groups for Preventive Maintenance include:

- Determining the level of maintenance to be applied to the facilities in their custody. Actually this is determined jointly by operations and the PM Engineer —but it is the responsibility of operations.
- Properly operating, caring for, cleaning, and in specified cases lubricating, making adjustments and correcting minor defects.
- Insuring that adequate preventive Maintenance is applied to all equipment by reviewing and approving the program recommended by maintenance.
- Evaluating results and the performance of equipment to achieve the most economic level of maintenance.
- Cooperating to the fullest in the difficult problem of making equipment available for approved Preventive Maintenance service and inspection frequencies.

Maintenance. The basic responsibility for developing, installing and administering the Preventive Maintenance program rests with the maintenance organizations. While the Departmental Maintenance Staff assists in policy, procedure, evaluation, control and in providing liaison with other departments and between districts, the District Maintenance Staff administers the program.

Specifically these responsibilities include:

Planning. The Preventive Maintenance Engineer in each District Planning Section is responsible for the development, installation and administration of the District Preventive Maintenance program. The steps in developing and installing the program have been listed. The administration of the program involves the continuous analysis of the recorded data. The results must be continuously evaluated. It is here that the experience, judgment and initiative of the PM Engineer are important. However, the greatest single requirement is the PM Engineer's skill in coordinating the thoughts and efforts of all agencies involved. He must be a staff man of the highest caliber.

Execution. The execution of approved Preventive Maintenance work is generally a responsibility of maintenance personnel and will be handled on work orders in the normal planning and scheduling procedures. An exception to this is the execution of part of the operating Preventive Maintenance such as lubrication, adjustments and correcting minor defects by operating personnel.

Inspection Agencies. The point at which responsibility for Preventive Maintenance ends and corrosion or metals inspection begins is a difficult line to draw. Here is the way we have divided things:

In our organization, metallurgical inspection is a responsibility of the District Safety Section. The bulk of their inspection work involves tanks and vessels. We have simply assigned to them what could be called the administration of preventive inspection on tanks and vessels. They keep the records, determine frequencies and originate inspection work orders for operations approval.

Engineering. The engineering function in the district, department, and including the general Engineering Department itself, plays an important part in Preventive Maintenance: Engineering responsibilities in relation to Preventive Maintenance are as follows:

1. **Construction.** Engineering's responsibility for construction of new facilities is an important factor in Preventive Maintenance by virtue of the necessity of its using standards, design principles, equipment selection and construction practices which achieve the optimum balance between investment and future maintenance costs. The economics of spending today's capital dollars to save future discounted after-tax repair dollars is a most important relationship.
2. **Specialized Technical Staff Service.** Engineering is responsible for furnishing specialized technical advice to maintenance on such matters as equipment study, materials research, methods analysis and equipment protective methods.

Before we leave engineering it is important to review the staff responsibility maintenance has to engineering

IDENTICAL EQUIPMENT INDEX — NUMBER: 69-P-1

Equip Class - 69 | Basic Design - A.S.A. | Manufacturer - Unknown | Model/Type/Fig No's. - 3435M

STANDARD PM WORK DESCRIPTION CODES

Operating Maintenance | Shutdown Maintenance | PM Overhaul

Equipment Number	Location	Operating Name	Stages	Size	Service Intensity Time	Service Intensity Starts	Service Intensity Index	Remarks
69-P-1	Plant Utilities Eng. Section	Centrifugal Pump	1	6x8x13				2/61 27LA3681
69-P-1A	" "	" "	1	"				27LA3681
69-T-1	Tank Farm	Transfer Pump	1	6x8x13				27LA3715
69-P-2	Plant Eng. Office	Centrifugal Pump	1	10x8x16				27LA3693

FIGURE 6—The equipment number has as its first two numbers the equipment class.

PREVENTIVE MAINTENANCE WORK CODES		Equipment Class Centrifugal Pumps
CODE NO.	WORK DESCRIPTION	
	Operating Maintenance	
OM-67-1	Oil Pump.	
OM-67-2	Change operations to spare pump.	
OM-67-3	Open suction and discharge valves and start spare pump for at least one minute.	
OM-67-4	Walk through inspection.	
OM-67-5	Check list inspection.	
OM-67-6	Grease bearings.	
OM-67-7	Inspect and tighten anchor and mounting bolts.	
	Shutdown Maintenance	
SM-67-1	Drain, flush and put new oil in bearing case.	
SM-67-2	Drain, flush and put new oil in bearing case and lubricate coupling.	
SM-67-3	Drain, flush and put new oil in bearing case, lubricate coupling, and inspect packing and repack if needed.	
SM-67-4	Drain, flush and put new oil in bearing case, inspect coupling for tightness on shaft, disassemble coupling for inspection of wear, and lubricate coupling.	
SM-67-5	Drain, flush and put new oil in bearing case, inspect coupling for tightness on shaft, disassemble coupling for inspection of wear, lubricate coupling, and inspect packing and repack if needed.	
SM-67-6	Drain, flush and put new oil in bearing case, inspect coupling for tightness on shaft, and check for loose coupling bolts.	
SM-67-7	Drain, flush and put new oil in bearing case, inspect coupling for tightness on shaft, check for loose coupling bolts, inspect packing and repack if needed.	
SM-67-8	Drain, flush and put new oil in bearing case, inspect packing and repack if needed.	
SM-67-9	Drain, flush and put new oil in bearing case, and check and record shut-in differential pressure.	
SM-67-10	Lubricate coupling.	
SM-67-11	Inspect coupling for tightness on shaft, disassemble coupling for inspection of wear, and lubricate coupling.	
SM-67-12	Inspect coupling for tightness on shaft, disassemble coupling for inspection of wear, lubricate coupling, inspect packing, and repack if needed.	
SM-67-13	Inspect coupling for tightness on shaft and check for loose coupling bolts.	
SM-67-14	Inspect coupling for tightness on shaft, check for loose coupling bolts, inspect packing and repack if needed.	
SM-67-15	Inspect packing and repack if needed.	
SM-67-16	Inspect packing and repack if needed, check and record shut-in differential pressure.	
SM-67-17	Inspect and recondition mothballed pump.	
SM-67-18	Mothball for seasonal shutdown.	
SM-67-19	Check and record shut-in differential pressure.	
SM-67-20	Check coupling alignment.	
	PM Overhaul	
OH-67-1	Remove pump and install spare unit. Overhaul pump removed.	
OH-67-2	Open casing for internal inspection and repair as necessary.	
		Equipment Class Centrifugal Pumps 67-1

FIGURE 7—Typical PM work to be done on a particular equipment class, such as centrifugal pumps shown here, is set up by code number.

of furnishing results of experience and realistic recommendations (based on factual data, no opinion) on design and construction of facilities. Maintenance and operations must do more than criticize engineering—they must measure and furnish factual data on which corrective action can be taken.

Supporting Services. 1. Cost Accounting is responsible for furnishing the accounting necessary so that Preventive Maintenance can be economically controlled.

2. **Materials Control.** A well organized and optimum stocked warehouse is indispensable to a successful Preventive Maintenance program. In an operation as large and as scattered as any integrated oil company, standardized catalog numbers and electronic data processing is a necessity.

Preventive Maintenance is generally thought of as a set of procedures. Sometimes we hear it called a philosophy. There are many fine definitions, all of which attempt to describe a rather complex activity. Perhaps the best definition of PM would be to simply call it the application of the principles of management to the task of keeping machines in profitable production. With this viewpoint it is obvious that there are no recipes for PM. There is no stock set of solutions to maintenance problems. The principles of management applied with a little technical knowledge and experience to maintenance will automatically end up in economic PM tailored to fit the situation. Management authorities use different words in listing the functions of management. However, if we say that PM is a *coordinated* and *organized* effort in *planning* and *controlling* maintenance to attain a profit *objective,* we include the essential management functions in our definition, and the term "profit objective" in our definition brings economics into PM. Generally we think of PM as a procedure to prevent costly equipment failures. We should also think of PM as a means of preventing costly maintenance. Oftentimes increased maintenance costs result in greater profits. But usually the homely truth is that the best way to save money is simply not to spend it. With the profit objective in mind the best kind of maintenance would be no maintenance—if it were possible. Without the profit objective in mind we are prone to let techniques exceed our purpose and PM may become a fancy set of procedures for doing unnecessary work.

The importance of the application of management principles cannot be over-emphasized. Preventive Maintenance must contribute to the profit objective of the enterprise. The letters PM should mean profit maintenance. Preventive Maintenance, in fact any maintenance, is justified only by the economic results it produces.

Originally presented before the Plant Maintenance and Engineering Conference and Show, Philadelphia, Jan. 27, 1960.

About the Author

J. F. Thornton is the general maintenance superintendent for the Natural Gasoline Department of Phillips Petroleum Company, Bartlesville, Okla. He directs and coordinates the maintenance activities of the various plants in the department. Holder of a B.S. degree in civil engineering from the University of North Dakota, he has spent his entire professional career with Phillips where he has held several positions including chief mechanical engineer and assistant chief construction engineer.

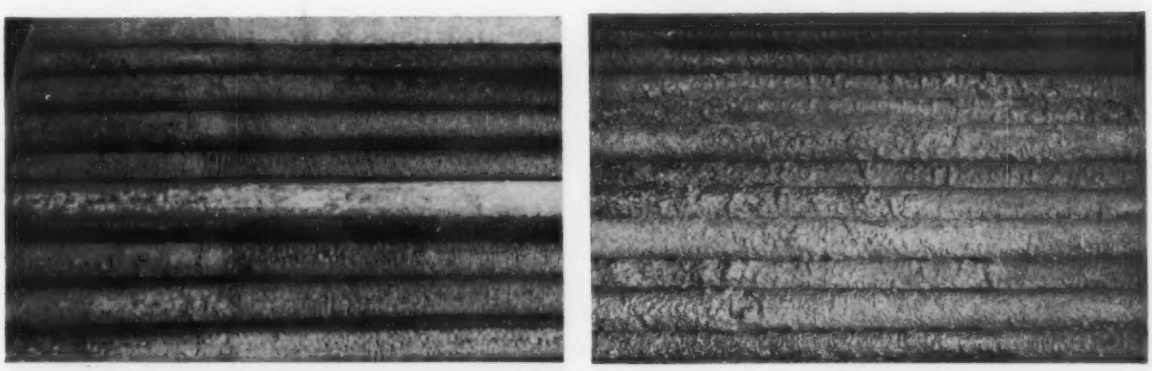
Does Fouling Rule Out Using Finned Tubes in Reboilers?

If you need more reboiler capacity, replacing plain tubes with finned tubes will give it to you. Studies show that fouling is not a problem

W. O. Webber
Humble Oil & Refining Company
Baytown, Texas

SUBSTANTIAL SAVINGS in equipment costs, or increased heat transfer capacity, can be gained by using low fin tubes instead of plain tubes in reboiler heat exchanger bundles. This has been our experience after three years' use of finned tubes in both clean and dirty reboiler service at the Light Ends Fractionation Unit (LEFU) columns in our Baytown refinery.

Why Use Finned Tubes? As a business decision, the use of finned tubes must be justified by economic considerations. One basis for such consideration is to compare fin and plain tubes. Two cases may be considered: (1) bottleneck removal projects, and (2) new projects. For reboilers, the need for additional capacity on an existing fractionating column can easily show costs for



Oil Outlet End — Oil Inlet End

FIGURE 1—Tube bundles look like this before cleaning.

retubing with finned tubes one-half to one-fifth of that for plain tubes requiring a new shell. For new installations the savings is less, with a ratio of 9/10 to 1/2. These conclusions flow from the calculated comparison of finned and plain tubes shown in the Appendix. These calculations, based on the assumption that all scale occurs outside the tubes, show that the heat input capacity per degree of temperature difference, UxA, is 80 percent higher for finned tubes.

We first became interested in using finned tubes in reboilers when it was desired to expand the capacity of LEFU equipment. In a new service one column did not have sufficient reboiler capacity—and another had too much! It was thought at first that it might be possible to simply switch reboilers. Unfortunately, the tower that required the increased capacity did not have enough room for the bigger reboiler. It was decided then to consider increasing reboiler capacity with finned tubes.

Fouling. The fact that finned tubes would substantially increase heat transfer capacity was well known. Indeed, Humble had used finned tubes in other applications. However, none of the previous applications involved operating conditions where heavy fouling would be encountered. There was a serious question as to the usefulness of a finned type tube under fouling conditions. It was felt that the added heat transfer capability provided by the fins would soon be nullified by the deposits. Further, it was felt that it might prove far more difficult to clean finned tubes than plain tubes.

Laboratory Studies. Since the fouling and cleaning problems seemed to be paramount, it was decided first to undertake some limited laboratory investigations of the fouling characteristics and cleanability of single finned tubes. The laboratory results strongly indicated that, at worst, finned tubes were no different than plain tubes in cleanability. There was some indication that finned tubes would not foul as readily as plain tubes and that once dirty, would be easier to clean.

Field Studies. A field investigation was then made at an installation where a finned tube condenser was operating in dirty service. The unit condensed reflux and product taken overhead from a rerun tower. The product was a cracked, sour, H_2S-containing 380° F

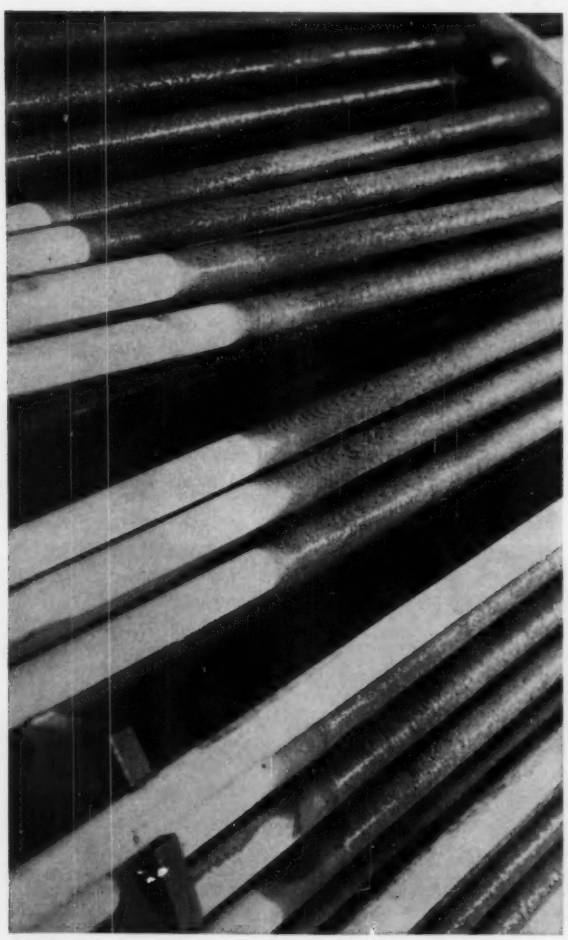


FIGURE 2—Tube bundle after cleaning oil outlet end.

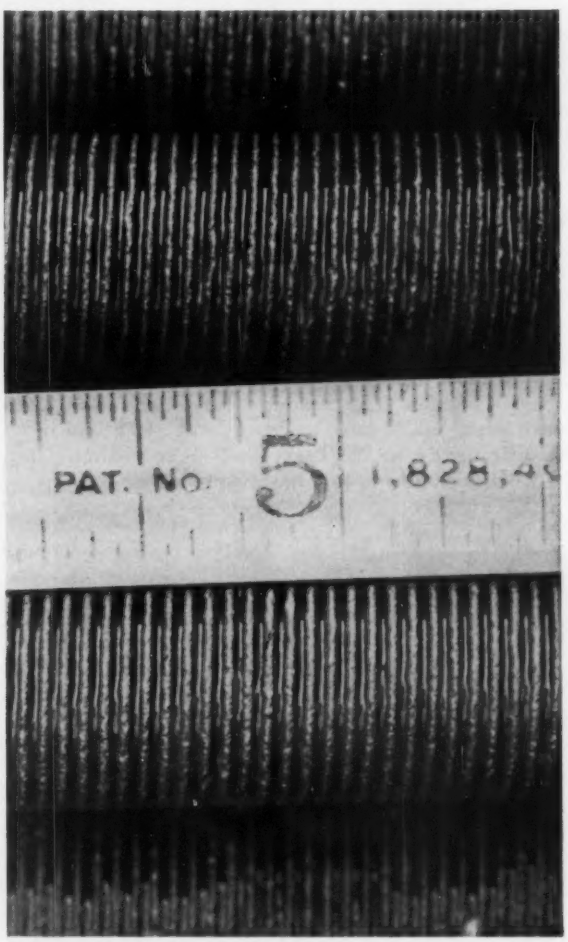


FIGURE 3—Fins damaged by sandblasting.

Can you use finned exchanger tubes in heavy fouling service? Humble's three year study shows their high heat transfer rate makes fouling easier to tolerate than when using plain tubes.

end-point stock. Formerly, the condenser contained plain tubes on triangular pitch. The rapid rate of fouling and frequent cleanings made the plain tube bundle inadequate and it was decided to provide greater capacity by going to finned tubes using the same tube sheets with triangular pitch. At the time of this field investigation, the unit had been in operation for approximately four years. While no heat exchanger coefficients were obtained, the load on the condenser was the same as or slightly higher than it was before the switch to finned tubes.

A comparison of the operations of the plain and finned tube bundles, shown in Table 1, together with our own work with finned tubes, convinced our group that we should go ahead with replacement of plain tubes with finned tubes.

TABLE 1—Operating Comparison of Plain and Finned Tubes

	Plain Tubes	Finned Tubes
Temperature, °F, gasoline out;		
Clean	125	95
Dirty	150	110
Cleaning: Cycle, Months	3	11
Time, Hours	20	6
Required Water Pressure	200	80
Fouled: Shell Side (Gasoline)	Very Much	Much
Tube Side (Water)	Little	Little

Cleaning Comparison. One of the first reboilers that was retubed with finned tubes was one in deisopentanizing service, charging sweetened plant pentanes. This feed stock fouled the reboiler tube bundle severely in a very short time—about a 6-month period. A triangular pitch plain tube bundle was replaced by a return-bend, square pitch finned-tube reboiler bundle.

After approximately six months service, the column was brought down for reboiler cleaning. Figure 1 shows the condition of the tube bundle before cleaning and Figure 2 shows it afterwards. It can be noted in Figure 2 that the outer tubes can be cleaned completely by conventional methods, while the inner ones cannot be completely cleaned. This, of course, is normally the situation with any type tube bundle.

Figure 3 shows the damage done to the fins by sandblasting. This is not considered serious, but it does indicate the need for care during cleaning.

On the basis of this experience and engineering considerations, we conclude that the high heat transfer capacity of the finned tube as compared with plain tube made it possible to tolerate fouling for a longer period

TABLE 2—Heat Transfer Coefficients of Lefu Reboilers

Service and Type of Reboiler Tube	Total Heat Transferred Btu/Hr x 10^{-6}	$\triangle T$, °F	Outside Area of Reboiler Square Feet	Heat Transfer Coefficient U_o, Btu/Hr/°F/Sq. Ft. of Outside Area	Total Tube Length In Bundle, Ft.	Heat Transfer Coefficient, U_l, Btu/Hr/°F/Ft. of Length
Deisobutanizing Alkylate FINNED	33.5	45	4,041	184	10,700	69.6
Deisobutanizing Alkylate FINNED	25.0	52	2,730	176	8,308	57.9
Deisobutanizing Alkylate PLAIN	44.0	69	4,240	150	25,910	24.6
Butane Splitting PLAIN	20.6	135	1,330	107	8,130	18.8
Butane Splitting PLAIN	30.6	83	1,480	241	9,046	40.7
Pentane Splitting FINNED	26.8	79	4,665	73	12,980	26.1
Depentanizing Alkylate. PLAIN	7.43	46	1,400	115	8,557	18.9

of time before the heat flow resistance became a limitation.

Operating Comparison. This experience led to the installation of more low finned tube bundles on other fractionating column reboilers. After a period of about one year of operation with four finned tube reboiler bundles, data were obtained on seven columns for comparison of fin and plain tubes. In the only comparable operations, the actual advantage for finned tubes appears greater than that predicted by calculation as detailed in the Appendix. The plant data are presented in Table 2, which shows the results of tests made to determine the heat transfer characteristics of LEFU reboilers. The over-all coefficients (U_o) shown in this table are based on total outside area. The only direct comparison that can be made is for the reboilers in deisobutanizing alkylate service. The heat transfer coefficients (U_o) of the two finned tube bundles, 184 and 176, are slightly higher than the coefficient of the plain tube bundle, 150. However, when the heat transferred by a one-foot length of tube is compared (U_1) the finned tubes are found to have transferred two and one-half times the amount of heat transferred by plain tubes, 69.6 and 57.9 as compared with 24.6. The greater advantage for finned tubes indicated by the data, as compared with that indicated by the sample calculation shown in the Appendix, may be a result of different fouling conditions for the first three operations shown.

The remaining data in the table does not permit direct comparison of fin and plain tubes in identical services, but may be of interest as plant data. In toto, they infer the superiority of finned tubes.

The pentane splitting column reboiler has a lower heat transfer coefficient than the other finned tube, kettle-type reboilers tested. This low coefficient may be the result of a dirty tube bundle.

As a result of the operating data accumulated over a three-year period, it has become accepted practice at Baytown to fabricate steam reboilers with finned tubes. They are specified as U-tubes to avoid cost and maintenance of a floating head, and on a square pitch to facilitate cleaning.

ACKNOWLEDGMENT

The author appreciates the inspection and test work done by Roy Chambliss and J. C. Davis of Humble, and D. W. McEachern formerly of Humble.

APPENDIX

A simple, straightforward comparison of plain and finned tubes can be made for a reboiler by calculating the UxA for one foot of tube length. Assuming a given quality steam and a given fractionating tower pressure and bottoms product quality or vapor pressure, the LMTD is fixed, and the heat input capacity then is measured directly by UxA. This comparison is shown in the following table.

Calculated Comparison of Plain and Finned Tubes in Steam Reboiler Service

Basis	
Evaporating hydrocarbon coefficient	300 Btu/hr/ft²/° F
Condensing steam	1500 Btu/hr/ft²/° F
Fouling factor: inside	0 (1/h)
outside	0.001 (1/h)
Size of tube	¾" OD
Length of tube	16 BWG
Gauge of tube	1′
Ratio outside to inside surface: plain	1.21
finned	3.84
Surface per foot: plain	0.1963 ft²/ft
finned	0.4960 ft²/ft
Define: $U = 1 \div \Sigma\, 1/h$	

Comparison							
Type Tubes	Plain			Finned			
Resistances	r_i	$\frac{A_o}{A_i}$	$r_o = r_i \frac{A_o}{A_i}$	r_i	$\frac{A_o}{A_i}$	$r_o = r_i \frac{A_o}{A_i}$
Steam	.0007	1.21	.0008	.0007	3.84	.0027
Metal	.0002	1.10	.0002	.0002	1.90	.0004
Dirt	.0010	1.00	.0010	.0010	1.00	.0010
Hydrocarbon	.0033	1.00	.0033	.0033	1.00	.0033
Total = total r's, outside			.0053			.0074
U = 1/R			189			135
A per foot, ft²			.1963			.4960
U_A per foot			37			67
Ratio fin/plain $U_A = Q/\Delta T$			1.81			

This calculation, based on more or less typical and reasonably clean conditions, shows an 80 percent gain for fin over plain tubes. This is the extra heat input to be gained per cubic foot of reboiler volume (fixed shell). The gain per dollar of investment is obtained, excluding shell cost considerations, by dividing the U_A's by their respective costs for plain and finned tubes. ##

About the Author

W. O. Webber is a staff engineer for Humble Oil & Refining Co., Baytown, Texas, where he designs and develops new control systems. Holder of a B.S. degree in chemical engineering from the University of Oklahoma, he has been with Humble 21 years. Work has included light ends recovery and fractionation, crude distillation, aviation gasoline, manufacture, refinery coordination, lube production, economics and advanced instrumentation. Webber has also taught in Humble's Practice School for Junior Engineers.

New Costs for Hot Carbonate Process

These data, which include three process variations, extend the economics of hot carbonate CO_2 removal to systems as large as 240 million standard cubic feet per day

Sidney Katell and John H. Faber
U.S. Bureau of Mines, Morgantown, W. Va.

THIS STUDY presents the economics of the hot carbonate purification process for removing CO_2. It considers three variations of the process in order to meet the design specifications, which call for a feed-gas flow of 10 million standard cubic feet per hour, with CO_2 inlet concentrations of 10, 20, and 30 percent and exit CO_2 values of 5, 2, 1, 0.5, and 0.1 percent. Inlet pressure and temperature are 350 psig and 300° F., respectively.

Estimated capital costs and operating costs are shown in Table 1.

TABLE 1—Capital Cost

Exit-Gas CO_2 Concentration	Feed-Gas CO_2 Concentration		
	10%	20%	30%
5 Percent	$1,131,200	$2,191,900	$3,507,300
2	1,718,600	3,057,300	4,332,400
1	2,186,000	3,559,500	4,926,700
0.5	2,515,100	3,879,800	5,379,900
0.1	2,828,400	4,198,800	6,033,800

Operating Cost, ¢/M scf of Feed-Gas

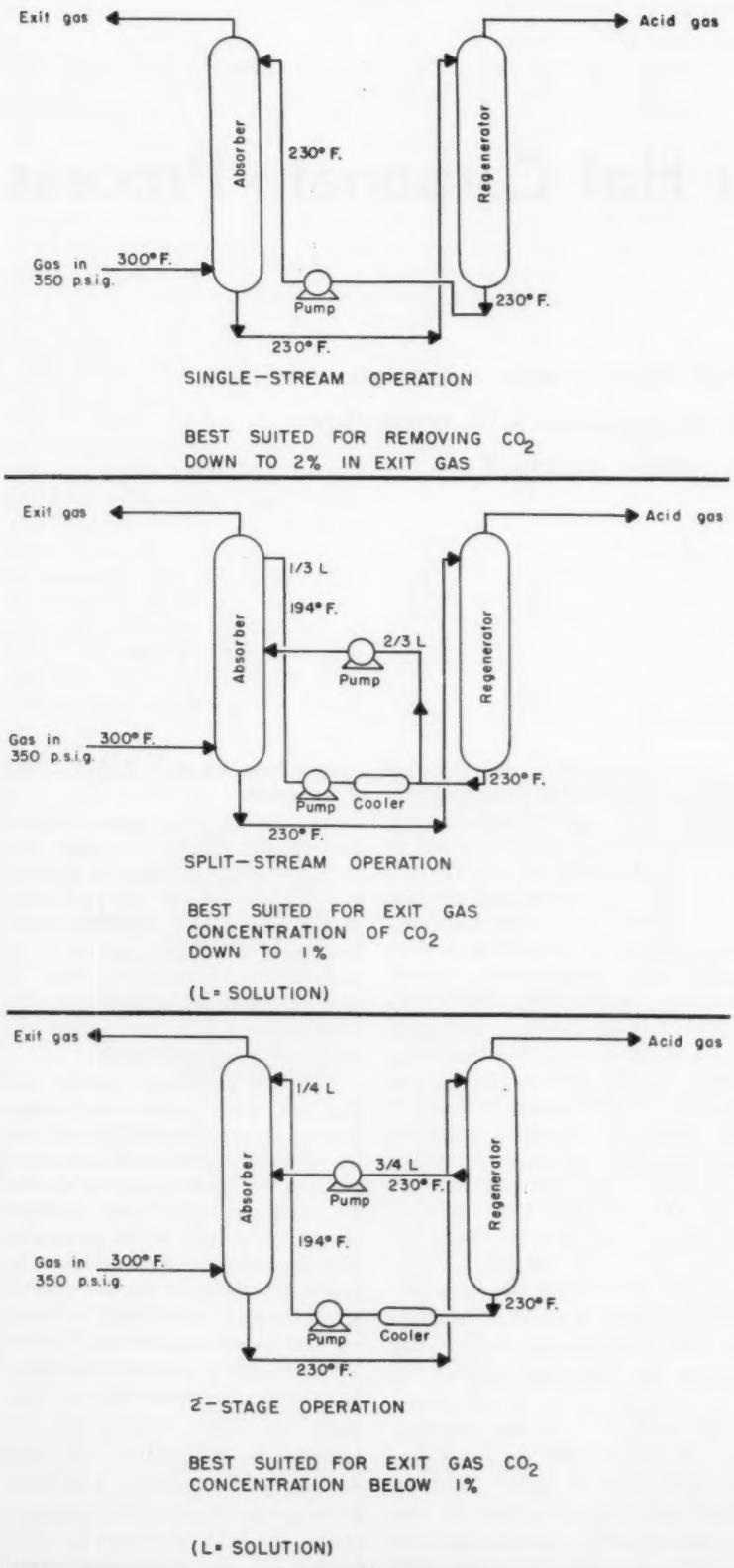
Exit-Gas CO_2 Concentration	Feed-Gas CO_2 Concentration		
	10%	20%	30%
5 Percent	0.74 ¢/M scf	1.25 ¢/M scf	1.80 ¢/M scf
2	.96	1.45	1.99
1	1.08	1.59	2.15
0.5	1.13	1.62	2.18
0.1	1.19	1.70	2.33

The major items in the operating cost are regeneration steam, electric power, labor, and depreciation. Steam amounts to 40-50 percent of the total operating cost, while depreciation and power account for 15-20 percent each. The remaining 35-45 percent is charged to cooling water, labor, maintenance, payroll overhead, supplies, and indirect cost.

The hot potassium carbonate purification process for removing carbon dioxide in synthesis gas was developed by the Bureau of Mines.[1,2] Its application to various industrial gases is rapidly increasing in number both in this country and abroad. Several recent articles[3-8] have discussed the process and to some extent the economics of the operation. However, this information has been limited to systems of up to 100 million scf (60° F, 30 inches Hg. dry) per day of feed gas. This study extends the scope of these data to a feed system of 240 million scf per day operating at a pressure of 350 psig and an inlet temperature of 300° F., with an initial CO_2 content of 10, 20, and 30 percent. CO_2 specifications for the exit gas from the purification system were set at 5, 2, 1, 0.5, and 0.1 percent.

Any purification system—amine, hot carbonate, water, or other—has its own optimum range of application. In the case of hot carbonate, the process is best applied at pressures above 200 psig and to a gas with CO_2 concentrations above 10 percent. There are exceptions to this rule; however, for most cases the designated limits will apply.

The hot carbonate process and the now more widely used amine process for removing CO_2 are similar in many respects. The principal items of equipment, such as absorbers, regenerators, and solution pumps are essentially the same. The two factors that account for the major differences in the two systems are the size of liquid heat exchangers and steam requirements. In the hot carbonate system the absorption and regeneration both occur at relatively the same temperature, the temperature differential depending on the cycle employed. Therefore, when compared with amine purification, the heat exchanger is either smaller or else completely elimi-



nated. In the case of amine the liquid heat exchangers might involve as much as 20 percent of the capital investment, depending upon design conditions.

The regeneration efficiency (CO_2 removed per pound of steam used), using hot carbonate, is higher than with amine, and this, coupled with lower cooling water requirements and elimination of exchangers, explains the lower operating cost for the hot carbonate process.

Another advantage of hot carbonate is its ability to remove both H_2S and COS in addition to the CO_2. The quantity of sulfur removal is related to the quantity of CO_2 removed in the system. This relationship will be discussed in a separate report.

Three variations of the hot carbonate process are used in this study. They are: (1) Single-stream operation; (2) split-stream operation; and (3) two-stage operation. Simplified flow diagrams of these processes are shown in Figure 1.

PROCESS DESCRIPTION

Single-stream or conventional operation is best suited for CO_2 removal to 2 percent in the exit gas. The feed gas enters the base of the Raschig ring packed absorber flowing countercurrent to a 35 percent potassium carbonate solution entering the top of the unit. The foul solution from the bottom of the absorber enters the top of the packed regenerator where the acid gases are removed by means of stripping steam. The regenerated solution is then pumped back to the top of the absorber.

The treated gas is sent on for further processing or, in the case of a natural gas installation, is cooled for pipe line transmission.

Split-stream operation is used for removing CO_2 down to 1 percent. The feed gas follows the same flow pattern as in the single stream. The

FIGURE 1—Shows the three variations of the hot carbonate CO_2 removal process discussed here.

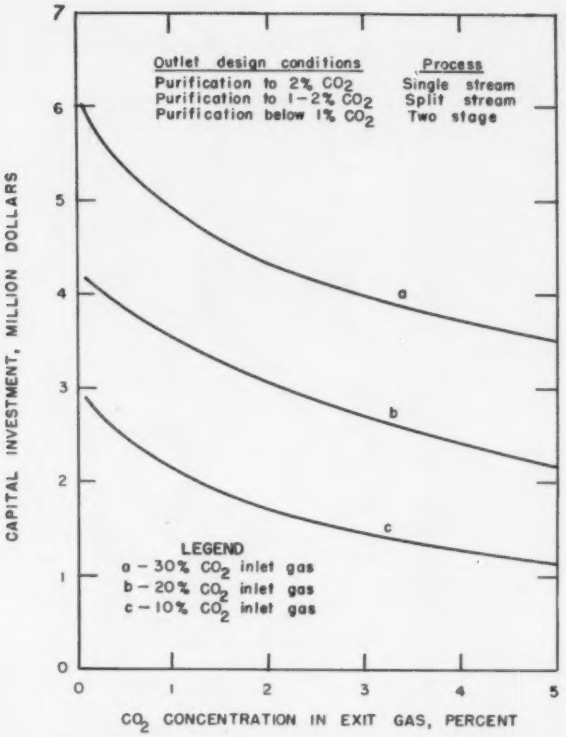


FIGURE 2—These are the capital investment costs for three process variations and three different feed gas concentrations.

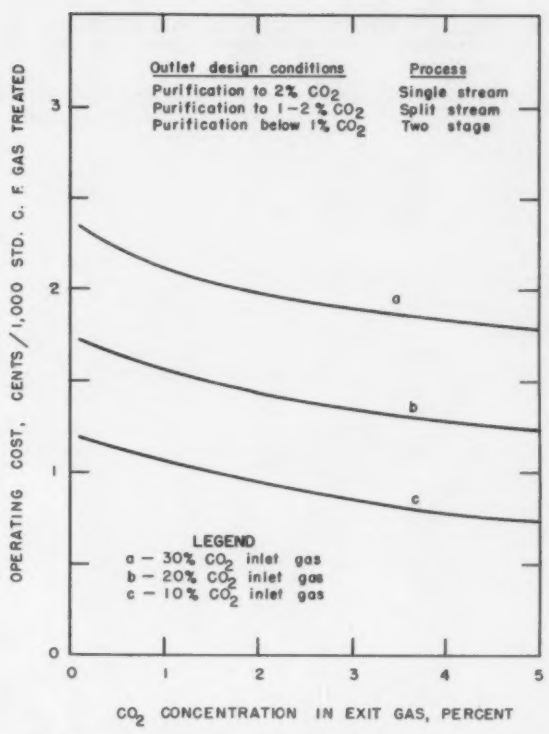


FIGURE 3—These are the operating costs for three process variations and three different feed gas concentrations.

difference between the two systems is that, in the split stream, part of the solution leaving the regenerator, approximately one-third, is cooled and then pumped to the top of the absorber. The remaining two-thirds is not cooled and is fed to the absorber somewhere near the midway point. In the split-stream system the tower is higher and the liquid loading lower in comparison to the single-stream operation.

Two-stage operation, for systems operating with a CO_2 outlet below 1 percent, utilizes a split-stream operation in both the absorber and regenerator. The feed gas follows the same flow pattern as in the single- and split-stream processes. The carbonate solution flow differs to the extent that 75 percent of the solution, drawn from a midpoint on the reactivator after being partly regenerated, is fed to the absorber near its midpoint. The other 25 percent is fully regenerated, cooled, and then fed to the top of the tower.

ESTIMATED CAPITAL AND OPERATING COSTS

Tables 2, 3, and 4 list both the capital cost and the operating cost for the purification systems, as designed for the conditions previously outlined. These tables include additional pertinent operating-design data. In the design of both the absorber and regenerator, a closer approach to equilibrium between the gas and the solution was assumed, resulting in an optimum steam requirement. Figure 2 shows graphically the relationship between capital investment and inlet and outlet CO_2

TABLE 2—Hot Carbonate Purification System
10 Million SCFH Gas Feed—30% CO_2 Inlet
Data Summary

Process	SINGLE STREAM		SPLIT STREAM	TWO STAGE	
CO_2 Exit Concentration, Percent	5	2	1	0.5	0.1
Cap. Investment	$3,507,300	$4,332,400	$4,926,700	$5,379,900	$6,033,800
Oper. Cost*	1.80	1.99	2.15	2.18	2.33
HP Req.	3,810	4,430	4,260	4,140	4,110
Cool. H_2O gpm	17,000	18,500	25,590	23,900	26,100
Steam Req. lb./hr.	292,000	317,400	348,600	353,000	383,720
K_2CO_3 $/yr.	$28,100	$30,500	$31,300	$30,000	$30,300

* Cents per 1,000 scf feed gas, without return on investment.

TABLE 3—Hot Carbonate Purification System
10 Million SCFH Gas Feed—20% CO_2 Inlet
Data Summary

Process	SINGLE STREAM		SPLIT STREAM	TWO STAGE	
CO_2 Exit Concentration, Percent	5	2	1	0.5	0.1
Cap. Investment	$2,191,900	$3,057,300	$3,559,500	$3,879,800	$4,198,800
Oper. Cost*	1.25	1.45	1.59	1.62	1.70
HP Req.	2,237	2,875	2,970	2,852	2,755
Cool. H_2O gpm	10,200	11,900	16,976	16,150	17,372
Steam Req. lb./hr.	175,500	204,400	228,500	233,300	255,100
K_2CO_3 $/yr.	$17,900	$20,800	$21,700	$21,000	$20,300

* Cents per 1,000 scf feed gas, without return on investment.

New Costs for Hot Carbonate Process . . .

TABLE 4—Hot Carbonate Purification System
10 Million SCFH Gas Feed—10% CO_2 Inlet
Data Summary

Process	SINGLE STREAM		SPLIT STREAM	TWO STAGE	
CO_2 Exit Concentration, Percent	5	2	1	0.5	0.1
Cap. Investment	$1,131,200	$1,718,600	$2,186,000	$2,515,100	$2,828,400
Oper. Cost*	0.74	0.96	1.08	1.13	1.19
HP Req.	964	1,525	1,684	1,677	1,670
Cool. H_2O gpm	3,550	6,140	9,470	9,340	10,070
Steam Req. lb./hr.	61,200	106,000	128,000	134,500	147,900
K_2CO_3 $/yr.	$7,000	$10,800	$12,100	$12,300	$11,900

* Cents per 1,000 scf feed gas, without return on investment.

TABLE 5—Hot Carbonate Purification System
Estimated Annual Operating Cost—30 Percent CO_2 In—5 Percent CO_2 Out
Capital Investment—$3,507,300

			Percent
Direct Cost			
(a) Raw Materials and Utilities			
Electric—2,990 kw.-hr. x 24 x 330 x $0.0075/kw.-hr.	$177,700		
Cool. H_2O—17,000 gpm x 60 x 24 x 330 x $0.01/1,000 gal.	80,800		
K_2CO_3 (Annual replacement)	28,100		
Steam—292,000 lb./hr. x 24 x 330 x $0.25/1,000 lb.	578,200		
		$ 864,800	60.6
(b) Direct Labor			
96 man-hours @ $2.25 x 365	$ 78,800		
Supervision @ 15 Percent	11,800		
		$ 90,600	6.3
(c) Plant Maintenance			
10 men @ $5,000/annum	$ 50,000		
Supervision @ 20 Percent	10,000		
Material—50 Percent Labor	25,000		
		$ 85,000	6.0
(d) Payroll Overhead (18.5 Percent Payroll)		$ 27,900	2.0
(e) Operating Supplies (20 Percent of Plant Maintenance)		$ 17,000	1.2
Total Direct Cost		$1,085,300	76.1
Indirect Cost			
50 Percent Labor, Maintenance, and Supplies		$ 96,300	6.7
Fixed Cost			
Local Taxes and Insurance @ 2 percent of Capital Investment		$ 70,100	4.9
Depreciation @ 5 percent of Capital Investment		$ 175,400	12.3
Total Operating Cost		$1,427,100	100.0

Total gas feed to unit = $10 \times 10^6 \times 24 \times 330 = 79.2 \times 10^9$ std. c. f.

Operating Cost/1,000 std. c. f. = $\frac{\$1,427,100}{79.2 \times 10^6} = \$0.018$.

concentrations. Similarly, the operating costs are shown in Figure 3.

Equipment. The required equipment includes absorbers, regenerators, hot carbonate pumps, reflux and makeup pump, carbonate mix tank, carbonate storage tank, clean-gas knockout drums, centrifuge, reboilers, acid gas coolers, and acid gas knockout drum. All equipment is carbon steel with the exception of hot carbonate pumps, solution coolers, and reboiler tubes which are Type 304 stainless. To the cost of the principal items of equipment are added the cost of foundations, structures, buildings, insulation, instrumentation, piping, electrical work, and painting.

The complete cost includes indirect field labor, engineering, overhead, and administration, together with a contingency factor.

The method used to calculate the operating cost is illustrated in Table 5. The authors realize that bookkeeping or accountant methods will differ from company to company; therefore, adjustments to any of the items that enter into the calculation may be necessary for any specific application. One major cost item, the return on investment, has not been considered, since the range of anticipated return depends on the particular operator of the hot carbonate purification system.

For this study a 90 percent operating factor or a 330-day operating year was assumed. Actually, the unit should be capable of a 96 percent on-stream factor. Again, this would depend on a specific installation.

About the Authors

Katell Faber

Sidney Katell is chief of the process evaluation staff for the Appalachian Experiment Station of the U.S. Bureau of Mines, Morgantown, W. Va. In this position, he is responsible for the preparation of cost studies dealing with processes utilizing coal as the basic raw material. Katell received his B.S. degree in chemical engineering from New York University in 1941. Before joining the Bureau of Mines, he was with Westinghouse Electric Corp., and T.V.A.'s Chemical Engineering Department.

John H. Faber is a chemical engineer for the U.S. Bureau of Mines, Morgantown, W. Va., where he does process economic evaluation studies including material balances, equipment design, thermodynamic balances, and cost analysis—both capital and operating. He holds a B.S. degree in chemical engineering from the University of West Virginia and is a registered professional engineer. From 1947-53 Faber was assistant engineer in stream pollution control for West Virginia State Water Commission, and from 1953-56 he was a power engineer for E. I. duPont de Nemours & Co. He has been with Bureau of Mines since 1956.

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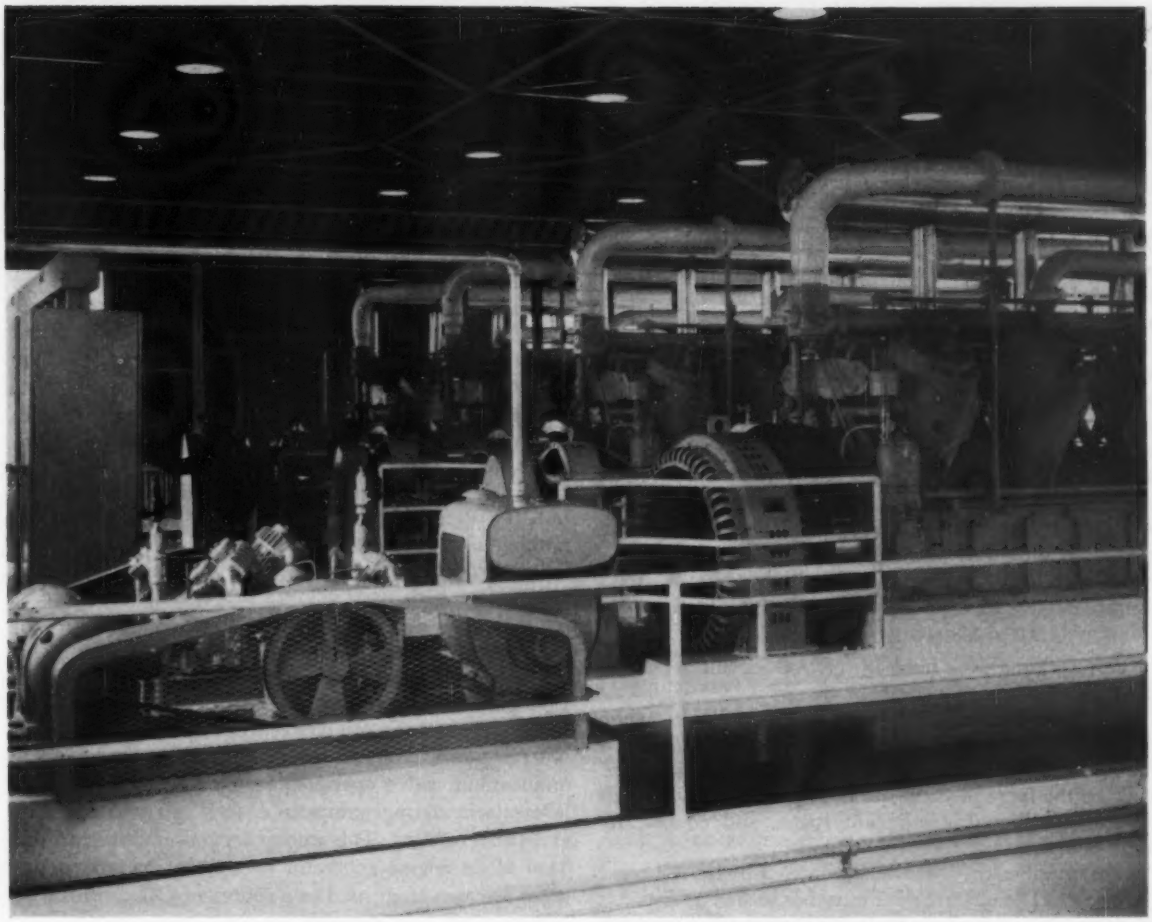


Electrical generators: Each plant must decide whether it will buy or generate its power.

Operator's Handbook for Gasoline Plants

Part 7—Electricity. One of a series that simplifies operations and equipment for the new and experienced operator in a natural gasoline plant

Manufacturing Department, Bay Petroleum Company, Division of Tennessee Gas Transmission Co., Houston

NONE OF US knows exactly what electricity is, but we understand how it behaves and through this knowledge we can make use of it. To understand electricity, there are certain terms and definitions that must be understood.

A good analogy between fluid flow (or hydraulics) and electrical flow is shown in Figure 36.

Electrical Formulas. In the early days of electrical experimentation, it was proven by George Simon Ohm that for a given metallic circuit, a definite ratio existed between the potential and the current. This resulted in a law that bears his name. The law that the ratio of the potential to the current in a given circuit is constant is called Ohm's Law, and is the fundamental law of the flow of electric currents:

$$R = \frac{E}{I} \quad \text{or} \quad \text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

By use of this law we are able to predetermine wire sizes, power losses, voltage drops, most economical voltages to use, and many other factors in designing a new installation.

Perhaps the most useful of electrical terms is power.

The unit of power is the "watt." This is what is required to do the work, to pump the water, drive the fans, heat the buildings, etc. First, we must use a simple formula that will serve as a tool to increase our understanding of the electrical ingredients necessary to obtain this power:

$$\text{Power} = \text{Voltage} \times \text{Amperes}$$

The principle components of electrical power are volts and amperes. For direct current (DC) circuits, this formula is complete. So, to find watts, merely multiply volts × amps.

Unfortunately, this is not quite the case when figuring alternating current (AC) power. Here the voltage and current are seldom in phase; or put another way, the current either lags or leads the voltage by an angle between 0 and 90 electrical degrees (Figure 37). If angle A is 0°, current and voltage are in phase. The effective "volt amperes" or "power" will be the Volts × Amperes × the cosine of the angle of lead or lag. This cosine is called the *"power factor"*.

To calculate for AC power multiply volts × amps × p.f.

$$P = \text{Volts} \times \text{Amperes} \times \text{P.F.}$$

This formula will hold if the AC circuit is single-phase.

The largest rated single-phase motor available on the market is 10 hp. Motor manufacturers buy raw materials by the pound and sell them by the horsepower. Because the large physical size of single-phase equipment requires additional steel, plant space, and copper, no large equipment of this type is made.

It is possible to generate 2-phase, 3-phase, 6-phase, etc. power. The electrical industry has settled on 3-phase as the most economical. Such equipment has an added advantage in that no special starting devices are required. Using this three-phase equipment will alter the power formula slightly but will not complicate it as all we do is multiply by the constant $\sqrt{3}$ or 1.73.

The power formula in its final form now becomes:

$$P = \text{Voltage} \times \text{Amperes} \times \text{P.F.} \times 1.73$$

Source of Electrical Energy. In most locations where a plant is to be built it is necessary to decide whether to generate power or to buy it from the local power company. Any progressive power company will vigorously attempt to prevent the erection of other generating equipment in their territory. Their persuasive argument concerns costs of purchasing power from a company engaged in that business versus the costs of our making it in small batches. Purchased power can be bought for approximately one-third of the fixed annual charges on an auxiliary building. This excludes the additional cost of fuel, labor and maintenance.

Unfortunately, natural gas is often found in remote places, and consequently processing plants are located in the gas fields instead of in the large cities. Often the location is remote from large power stations. In such cases the power company cannot offer the continuity of service that is necessary in an operation of this type.

Power companies, in their attempt to sell energy, state their outages in number of minutes per year. This can be misleading since a half second outage in a plant causes severe disruption of the process, gas loss, and curtailment of thruput. In cases where the outages are excessive, it is much more economical to generate power even at the higher cost per kilowatt hour. Each plant site must be given careful study before selecting the source of power.

Even in the case of a dependable power source from a local utility, the risk of severe storms, tornadoes, hurricanes, and the like causing an outage running into a matter of weeks is apparent. It is common practice to put in a stand-by generator even in this case. This does nothing to alleviate short outages but allows operation when the down time stretches out into several hours or more. Here high fixed charges supply only insurance.

Often it is necessary to have still another source of power which may be called emergency power. This operates essential functions in case of power failure. Emergency systems are designed to come on automatically when the primary source of power fails. These systems power essential functions such as radio communications, valve operators for emergency shutdowns, lube oil circulating pumps in case of gas turbines, and sometimes lighting. This emergency power can be in the form of an engine generator or a set of batteries. Batteries are also often used as a source of DC control.

Auxiliary Switchboard. The auxiliary switchboard is the very heart of the plant. At first glance it seems to be a complicated device, but can be greatly simplified when broken down into its component parts. Its con-

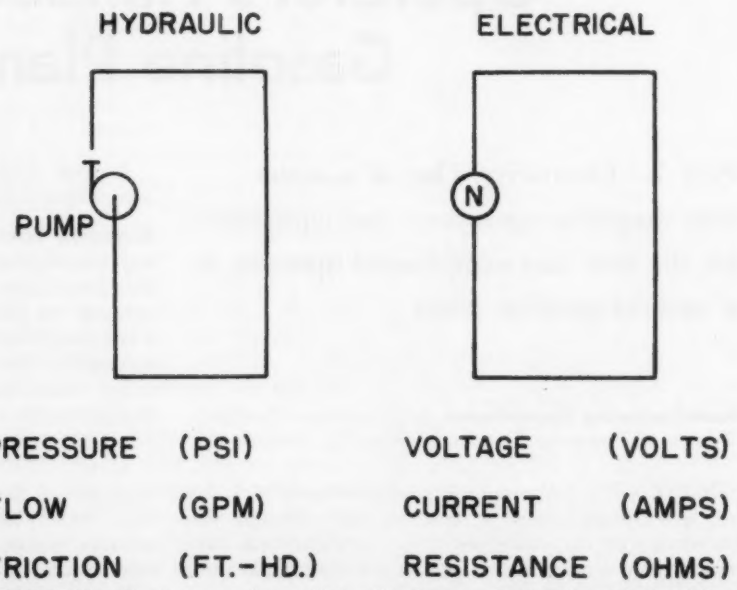


FIGURE 36—Here's the analogy which exists between hydraulics and electricity.

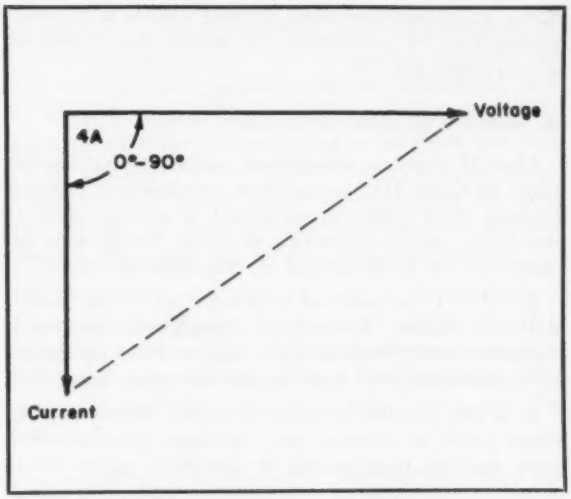


FIGURE 37—In alternating current, voltage and current may be out of phase by an angle between 0 and 90.

struction consists of separate cubicles or panels. The swinging panel locates instruments pertaining to the total load, or instruments in common to the various panels. There are bus bar voltmeter, incoming machine voltmeter, frequency meter, power factor meter and synchroscope.

The frequency of the alternating current in a circuit is equal to the following formula:

$$f = \frac{nr}{2 \times 60}$$

Where f = the frequency in cycles per second, n = number of poles, and r = revolutions per minute. As the number of poles is always fixed for our purpose, frequency varies directly as the speed of the machine. The power factor meter measures a function of the angle (degrees lead or lag) between voltage and current in AC circuits. Power factor meters indicate this function directly.

The synchroscope is an instrument that indicates the difference in phase and frequency between the alternators. It shows whether the machine to be synchronized is running fast or slow. The pointer rotates clockwise if the machine is running fast and counterclockwise if it is running slow. When the pointer remains stationary pointing upward, the machines are in synchronization. By using two synchronizing lamps one system is a check against the failure of the other.

When power is plant generated, the switchboard has generator panels and the various distribution panels that feed the buildings, starter racks, lighting transformers and so forth.

For the purpose of operation the most important instruments on the switchboard are those on the generator panels. These instruments make possible correct operation by indicating electrical malfunctions. The panels usually contain a DC ammeter, AC ammeter, kilowatt meter, and kilovar meter. Assuming no instrument error, any two of these instruments that read identical with the same two instruments on any adjoining generator panel would indicate proper parallel operations of the two machines.

We have four instruments here to serve as a check against the failure of any of the others. Of the four, the most important instrument to the operator is the kilowatt meter. This meter indicates the power being developed by the engine driving the generator. The first responsibility should be to balance this load on all machines. If the generators are equally excited all four instruments on each panel will read exactly as their counterparts on the adjacent panels. Once the kilowatt meters balance (each machine is carrying the same useful load), the AC amps, DC amps, and kilovars should also be balanced. If they do not, it indicates that one alternator is either over or under excited. An electrician will then reset the field rheostat and voltage regulator on each machine to give the proper excitation.

Distribution Systems. After the source of power has been decided upon and brought into the auxiliary switchboard bus bars, it is necessary to distribute this power to the various plant motors and other electrical devices. Actually, a distribution system is a continuation of the switchboard bus bar. A common distribution system around plant installations results in the use of a direct buried ungrounded 3-wire system. In this system we depend upon driven ground rods, cold-water piping, and bare connecting wire for the grounding of electrical devices. Because of copper's location in the galvanic series with respect to steel pipe, buried bare copper can result in an increase in the amount of cathodic protection required. As an alternate, a 4-wire grounded distribution system is now being used which has the added advantage of equipment protection. The possibility of burning out equipment, should the second phase go to ground, is eliminated since in the 4-wire system the breaker will open on single phase grounding. Another interesting application is the open Delta connection, which is found in instrument transformer connections. This is usually 120 volt 3-phase.

Methods of Installation of Distribution System. In older plants direct burial cable was used in the distribution system. Theoretically, if this cable was undamaged during installation or subsequent construction, it should last for fifty years. Practically this is not the case. A great deal of trouble with direct burial cable has been experienced, which in most cases leaves one alternative —to abandon the cable in place and install new cable. This cable also suffers much damage in South Texas, and other areas having clay soil due to soil stress.

It has become common practice to install underground cable in duct or conduit. By putting cable in a duct, a less expensive cable is purchased; and by providing a permanent wireway no other excavation costs become necessary. This is a considerable saving in costs, in convenience and effort. In addition, this system is maintained with comparative ease. All of this aids in reducing down time as well as maintenance cost.

Another method used in special cases is aerial or pole line distribution system. In many cases this is less expen-

sive construction and is also easy to maintain. Its chief disadvantages are unsightliness in the station yard and its vulnerability to outages caused by the weather.

Hazardous Locations. The purpose of the National Electrical Code is the practical safeguarding of persons and of buildings and their contents from hazards arising from the use of electricity. The code is sponsored by the National Fire Protection Association, an organization supported by the insurance companies of the United States. It sets up minimum safety standards and procedures. Another organization concerned is the Underwriters Laboratories, Inc. which is sponsored by the National Board of Fire Underwriters.

Every electrical installation is carefully checked for compliance with the code, and all items of electrical equipment used are approved by Underwriters Laboratories for use in the particular location in which it is intended.

The regulations of the National Electric Code are best illustrated by considering its applicability to a gasoline plant. This plant is covered by *Article 500—Hazardous Locations*. The plant is divided into three general areas:

Class I, Group D, Division 1

Class I, Group D, Division 2

Non-Hazardous Locations

By definition a Class I location is one in which flammable gases or vapors exist in "quantities sufficient" to render the resultant atmosphere explosive or ignitible.

Group D signifies atmospheres containing most petroleum vapors including natural gas. Division 1 means locations:

1. in which hazardous concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions,

2. in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage, or

3. in which breakdown or faulty operation of equipment or processes which might release hazardous concentrations of flammable gases or vapors, might also cause simultaneous failure of electrical equipment.

Division 2 locations are those:

1. in which flammable, volatile liquids or flammable volatile liquids or flammable gases are handled, processed or used, but in which they will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems,

2. in which concentration of these vapors is normally prevented by ventilation (in which the ventilation system might fail) or

3. locations adjacent to Division 1 areas.

Class II concerns atmospheres containing combustible dusts or Class III, atmospheres containing ignitible flyables, (i.e.) cotton or rayon lint in a textile mill. In the latter two classifications electrical installations are made safe by being housed in dust-tight enclosures.

In Class I locations safety is achieved by an entirely different system. Electrical installations are made explosion-proof. Frequently it is assumed that equipment to be explosion-proof must be gas-tight. This is not so.

It is not feasible to make a wiring system with its many joints in raceways and enclosures gas-tight. If it were feasible, there would be nothing gained by so doing, as the explosive atmosphere would enter whenever it became necessary to open any of the enclosures housing apparatus. Subsequent operation of the apparatus would explode the trapped atmosphere. Unless the enclosures were strong enough to resist the pressures developed, they would burst or at least allow the escape of flames. In either case ignition of the surrounding atmosphere results. The enclosures need to be strong enough to withstand, without damage, the pressures of the explosions and be tight enough to prevent issuance of flames. Every precaution is taken to make them flame-tight and strong enough to prevent any damage if an explosion occurs.

1. Static Electricity. To prevent a fire—whatever its cause—calls for the control of one or more of three elements which must be present to support combustion: (1) a flammable vapor, (2) air, and (3) a source of ignition. It is not possible in a plant to always prevent air and flammable vapors from combining in quantities sufficient to form an explosive mixture, so a possible source of ignition must be excluded from these areas. Sparks and arcs which result from switches, starters, relays and similar devices have been rendered harmless by explosion-proof installations; however, we have an ever present fire hazard in the petroleum industry from ignition which may arise from static sparks.

Suppose two materials are separated, for example, as gasoline flowing from the end of a pipe. Electrically speaking a charge will be left on the gasoline and an opposite charge on the pipe. The energy which is required to separate the two charges represents the increase in potential difference or voltage, between the two materials in question. Turbulence within a nonconducting liquid causes the separation of positive and negative charges. This occurs when petroleum products are transported or stored in tanks. While there are other causes of static sparks, the above are the ones which concern us.

Static electricity fire hazards can be overcome or controlled by several basic and effective approaches to the problem:

a. Bonding—When there are two points between which a sparking hazard can occur in the presence of

an explosive vapor-air mixture, a bond wire can be attached to both points. This prevents a difference in potential because it provides a return path for the electric charges; therefore, no charges accumulate and no spark occurs. This short-circuiting of the spark gap may not of itself prevent the accumulation of a static charge if both the objects thus bonded are completely insulated from ground. It does, however, eliminate the ignition hazard at the spark gap between these two objects.

b. Grounding—An electric circuit can be permanently or temporarily affixed to a piece of equipment by which the static charge which might otherwise accumulate is discharged to ground as rapidly as it is generated. This prevents the accumulation of charge and hence, the chance of sparks.

c. Controlled Generation—If the rate of generation of the charge can be kept less than the usual rate of its dissipation by leakage, a hazardous accumulation may be prevented. EXAMPLE: The liquid surface of a cone-roof storage tank accumulates static charge when the oil in the tank is agitated by some means such as rapid filling, or overshot filling, or air- or gas-blown liquid movement through the fill lines. The rate of generation is influenced by the turbulence of the liquid, and is increased by the presence of finely divided conductive material, such as water. If the turbulence can be controlled, the accumulation of charge upon the oil surface can be kept within safe limits; i.e., it can be kept from forming an incendiary spark along the surface. Obviously, grounding of the tank shell cannot prevent sparks along the surface of the oil.

2. Standard Protection of Typical Operations

a. Tank Trucks

(1) One end of a bond wire can be electrically connected to fill pipe (or to a steel loading rack), and the other end to a truck tank. This latter connection is made before the dome is opened, and it remains in place until the dome has been closed. This bond prevents a difference in electrical potential between the fill pipe and the tank truck. Surface sparks resulting from turbulence have not caused ignitions in tanks of this size. However, "downspouts" which extend into the body of the truck (used principally to reduce evaporation loss) should be of metal and of sufficient length to extend almost to the bottom of the tank.

(2) Static protection is required when tank trucks are unloaded by means of conductive or nonconductive rubber hose, flexible metallic tubing, or pipe from the bottom outlet, because a static spark can jump from the truck to the hose.

b. Tank Cars

(1) The inherently low resistance of tank cars to ground through the rails should *not* be assumed to prevent the accumulation *on the tank body* of a static charge of sufficient voltage to cause an incendiary spark. Therefore, tank-car loading and unloading through open domes requires the grounding protection against the accumulation of static charge on the tank car or against spark discharge to the fill pipe which is inserted into the dome.

c. Tank Ships

In the loading and unloading of steel ships and barges static charges may accumulate on the surface of the liquid due to loading. Bonding cables which are used between ship and shore are for protection against stray currents. (These cables are sometimes erroneously referred to as static cables.) The section on stray currents discusses the use of bonding cables between ship and shore. Grounding protection is again recommended.

d. Storage Tanks

The presence of water in oil is probably one of the most important factors in the ability of oil to generate static electricity. The largest static charges are built up on the surface of the oil when water is allowed to settle down from the surface of the oil. For this reason it is important that the velocity of flow, and the method of introducing the flow into a tank, be such as to keep from stirring up water bottoms and directing the water towards the surface of the oil.

Overshot fill lines are not recommended because of the waterfall effect on the oil surface and because of the action on the water bottoms. Tanks are particularly susceptible to static on the oil surface during the initial period of filling when the depth of oil is low. During the initial period it requires less agitation to cause flow to the oil surface. Also there is more air in a tank during initial filling and greater possibility of an explosive mixture.

Some companies limit the velocity of the incoming liquid stream to 3 feet per second until 6 feet of depth has been reached, or until the floating roof lifts (in the case of a floating-roof tank). Others introduce oil into tanks in a tangential direction to provide a swirl which carries water bottoms to the wall of the tank. A vane structure might be considered around the tank circumference at the bottom to provide a multitude of entrances, and directed so as to result in a swirl.

In the light of present knowledge, it is not possible to recommend any velocity of flow. Water bottoms, entrained water, and other factors are too varied to permit exact rules.

Floating-roof tanks are not subject to hazard from static electricity because there is no free oil surface on which charges can accumulate.

3. Lightning

a. Definition

Lightning may be defined as an electric spark in the atmosphere between the earth and a charged cloud, or

between two charged clouds. However, the major spark or lightning stroke referred to in this definition is not the only hazardous spark which may result from the presence of lightning clouds in the immediate vicinity of vapor-air mixtures or the vessels which contain them.

4. Tank Ships

Since the advent of the steel hull and steel masks, damage to ships from lightning has been infrequent, and no special protective design is required. Regulations of the U. S. Coast Guard and of some oil companies require that tank-vessel loading and unloading be suspended, and that all openings into tanks be closed, during lightning storms in the immediate vicinity.

a. Definitions

A stray current is any electrical current which may flow through piping and connected vessels which are normally located in more or less intimate contact with the ground.

Stray currents are of two types, according to their source:

1. Those which are caused by leakage from power lines: These have no definable limits.

2. Those which are generated by galvanic action associated with soil contacts: These usually are of low potential.

Stray currents from either source (1) or (2) are seldom of sufficient potential to cause sparks; but the arcs which result from contact breaking (such as opening a pipe run) may be hot enough to ignite petroleum vapors.

Telemetering. It is no longer necessary to travel to various points in a plant, or to have men stationed at remote locations, in order to make measurements or carry out necessary control operations. Telemetering can do a very efficient job of bringing measurements and control functions from remote points to control locations. The operator then has before him the complete conditions existing throughout the plant, and has at his finger tips means for making any necessary changes in gas flow or pressure anywhere in the system.

Any telemetering system can be broken down into three parts or units: a transmitting unit, a receiving unit, and an interconnecting means. The transmitting unit consists of a primary measuring element and a means of converting the measurement into an electrical signal. The primary measuring element can be a device for measuring static pressure, differential pressure, temperature, rate of flow, etc. The receiving unit converts the incoming electrical signal into mechanical motion to furnish an indication, a record, or control. The interconnecting means, as the name implies, joins the transmitting unit with the receiving unit.

Telemetering has been classified into five types:

1. **Current**
2. **Voltage**
3. **Frequency**
4. **Position**
5. **Pulse**

1. Current Type Telemetering. The current type of telemetering system is one in which the measurand (the quantity being measured and telemetered) is transmitted as a function of an electrical current; and at the receiving point, measuring this current, indicating, recording, reading out on a scale, chart or log sheet in units of the measurand.

To telemeter a gas pressure use is made of a bourdon tube, using its deflection as the pressure changes to position a brush on a slide-wire. The slide-wire is in series with a battery or constant-voltage source at the transmission location, with a millamper at the receiving terminal to reproduce the original pressure.

2. Voltage Type Telemetering. A voltage type of telemetering system transmits the measurand as a function of electrical voltage. At the receiving terminal a potentiometer or other voltage measuring device converts the voltage back to the original reading.

3. Frequency Type Telemetering. The frequency type of telemetering system is one in which the measurand, as it changes, varies the frequency of an alternating electric current. At the receiving location, the equivalent of a frequency meter, with scale or chart in units of the measurand, reproduces the original measurement.

4. Position Type Telemetering. A position type of telemetering system transmits and reproduces the measurand by positioning variable resistors or other electrical components in a bridge circuit arrangement so as to produce relative magnitudes of electrical quantities or phase positions at transmitting and receiving locations.

5. Pulse-Type Telemetering. Pulse-type of telemetering systems, as the name implies, makes use of various types of electric pulse techniques. Pulse systems transmit as a function of time and are independent of electrical magnitudes. These systems may be of the pulse counting type, where the number of pulses transmitted corresponds to the measurand, the pulse-width or pulse-duration type in which the duration of a pulse corresponds to the measurand, and pulse code systems, where a group of pulses of different widths and spacing correspond to the measurand. The pulse system of telemetering is more commonly used in the gas industry than all other systems added together.

(TO BE CONTINUED)

Save Money—Re-use Salt Cooling Water

Here's how adding salt water cooling towers to a once-through system met expansion needs for less capital investment and no increase in maintenance

Robert W. Keck
The California Oil Company
Perth Amboy, N. J.

SATISFYING EXPANDING product demands and the pressure of competition has required a continuous program of expansion from the first day our new Perth Amboy Refinery was put on stream in 1949. Continued growth was accompanied by many readjustment problems, but in 1955 we experienced a very sharp growing pain. In 1955, we undertook an attractive four year expansion program but realized that we had outgrown our cooling water facilities—both ends, pumping and disposal.

Original Facilities. Cooling water for the new 60,000-bpd Perth Amboy Refinery was sea water pumped from Arthur Kill. The pumping capacity installed consisted of two condensing turbine driven pumps, one serving as a spare, with the running pump having a nominal capacity of 35,000 gpm. A 42-inch cooling water main approximately 4,000 feet long carried the cooling water to the process plant area. Effluent cooling water was segregated into three separated sewer systems discharging to a nearby tidal creek. A clean or gassy effluent flows directly to the creek; an intermediate stream which is normally clean but which could carry light hydrocarbons, flows through an API separator; and a dirty and storm water drain which carries heavier oils flows through an API separator.

Cooling water pumping facilities as originally installed had a maximum pumping potential of 44,000 gpm, being limited by NPSH as well as system pressure drop. The spare capacity of approximately 9,000 gpm was used up by 1955 with expansions to crude units, cat cracker and platformer. Figure 1 shows the system as it existed in 1955.

EXPANSION NEEDS (ONCE-THROUGH SYSTEM) AND COSTS

Cooling water demands which existed in 1955 as well as future needs are tabulated in Table 1. Also tabulated are loads which existed at the separators as well as expected increased loads thru expansion. In addition to the requirements of expansion as shown in the tabulation, increased pumpage would require an additional cooling water main and new drain lines to carry increased water requirements to the process plants and effluents to the separator area. Increased facilities required to pump and dispose of the additional required cooling water as well as capital outlays required are shown in Table 2.

Nearly all of the additional facili-

Salt Water Cooling Towers Favored for Expansion

1. Used water available close to process area.
2. More economical where difficult construction conditions are encountered.
3. Disposal problems eliminated.
4. Allows for addition of incremental needs when required.

Save Money–Re-use Salt Cooling Water . . .

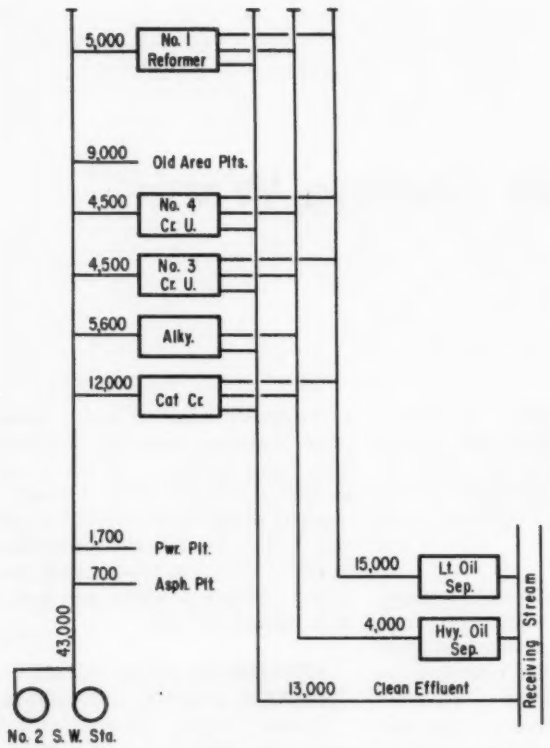


FIGURE 1—Here are the units served by the original once-through salt water cooling system.

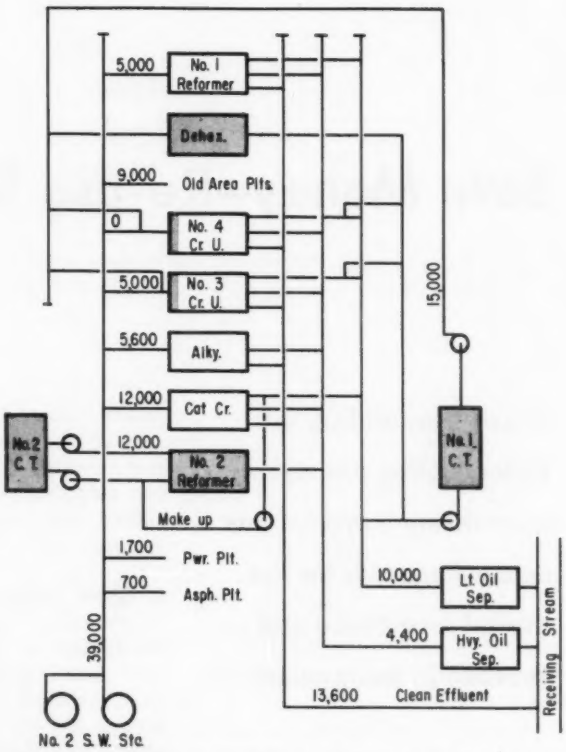
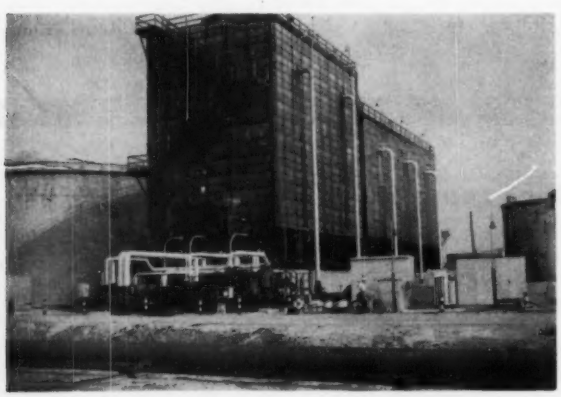


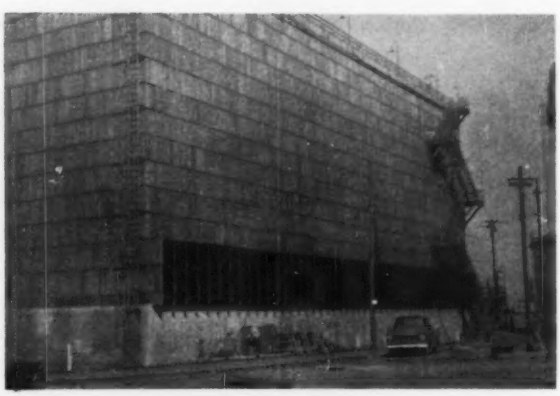
FIGURE 2—During expansion salt water cooling towers filled additional cooling needs shown shaded in the above diagram.

ties required with this expanded once-through system faced construction obstacles which resulted in high costs. Expansion of the pumping station would involve a new concrete intake channel. Required driver energy, steam or electric, was not locally available. A new cooling water main would require passing through tank fields and existing process facilities and, in addition, would have to cross a wide county road, a railroad right-of-way, and freight yard. Separators and sewers would have to be built in a poor swampy area which would result in high foundation costs.

Cooling Tower Considered. The effluent cooling water from the proposed new reformer would be clean and the cooling water requirement on the basis of estimated off-tower temperatures was 12,000 gpm. In addition to the reformer, cooling water requirements for the other expanded plants was estimated at 15,000 gpm. Existing effluent cooling



No. 1 cooling tower looking north.



No. 2 cooling tower.

TABLE 1—Expanded Salt Water Demands
Once-Through vs. Cooling Towers
(Gallons Per Minute)

	Peak S.W. Pump Demand	Load On Hvy. Oil Sep.	Load On Lt. Oil Sep.	Load On Clean Drain
Once-Through System				
1. 1955 Demand	43,000	4,000	15,000	13,000
2. Req'd Once-Through Additions	22,000	1,000	6,000	15,000
3. Total Demand	65,000	5,000	21,000	28,000
Cooling Towers				
1. 1955 Demand	43,000	4,000	15,000	13,000
2. Req'd C.T. Additions	—4,000	400	—5,000	600
3. Total Demand	39,000	4,400	10,000	13,600

water in the intermediate system was quite clean and lent itself to reuse after cooling. A thoroughly investigated cooling tower program was proposed and the advantages were these:

1. Reduction of total sewage effluent thereby:
   - Eliminating need for additional API separators
   - Eliminating need for additional effluent water mains
   - Reducing potential for water pollution
   - Reducing potential increase of separator maintenance costs
2. It eliminated the need for a new, long, expensive cooling water main (approx. 6,000 feet).
3. It eliminated the need for additional emergency cooling water storage tanks since cooling tower basins served as emergency reservoirs.
4. Total outlay for cooling towers was $1,675,000 compared to $2,260,000 estimated for once-through cooling facilities. The high cost of once-through facilities was due to difficult construction conditions, physical obstacles, and the need for piled supports for all structures and water mains.
5. Capital outlay could be stepwise with cooling towers where on a once-through system essentially all of the five year requirement would have had to be accomplished during the first expansion step.

Cooling Towers Financially Attractive. Table 2 shows that the total cost of the cooling tower facilities required for the complete expansion program was approximately $600,000 less than the estimated cost for equivalent once-through facilities. As stated, a major factor in this cost difference was the distance from the source to the process plants and the extremely difficult conditions which would confront installation of new cooling water mains.

A second factor which favored the cooling tower program was the possible stepwise construction and capital outlay. This enabled optimum use of capital funds for investment projects as compared with idle investment which would have resulted in the case of expansion (initially complete) of the once-through facilities. Based on after-tax rates of return which our company would anticipate and a two and three year deferred capital outlay on Steps No. 2 and 3 respectively of the cooling tower program, the 1955 value of the complete program was figured at $1,270,000 which compared very attractively with cost of the expanded once-through system—$2,260,000.

Operation and Maintenance. The first step of the No. 1 cooling tower construction consisted of two 3,000-gpm cells and was put into operation in the summer of 1956. This two-cell tower was probably the first one in salt water cooling service in the entire oil and chemical industry in this country. Cooling tower tower No. 2 has a 12,000-gpm cooling capacity and consists of four cells. This unit was placed into operation in February 1959. All towers were designed for very low drift losses to minimize corrosion of nearby equipment. No. 2 cooling tower completed the stepwise expansion which is shown schematically in Figure 2.

Operating and maintenance experience has been gained primarily from the first tower constructed, since the second 12,000-gpm tower has been in service less than a year. Operating problems have been insignificant and the towers operate essentially unattended; but are checked by a shift foreman as he makes his rounds.

Maintenance problems too have been minor. Through our experience to date we learned to avoid the use of metals of small cross-section. For example, corrosion experience with monel wire and banding has been poor. Failures of the coating on induced fan blades have indicated the need to go to alloys which was done on the newer tower cells. Wood sheathing retaining clips which were originally malleable iron are being replaced with monel. Structural steel members and motor casings have had to be coated to stem corrosion. # #

TABLE 2—Comparison of Capital Investments

Cooling Towers	
No. 1 C.T. (Cells 1 & 2) Incl. Distr. Lines	$475,000
No. 1 C.T. (Cells 3, 4 & 5) Incl. Distr. Lines.	300,000
No. 2 C.T. Incl. Distr. Lines	900,000
Total Required Investment	$1,675,000
Once-Through System Additions	
Expand No. 2 S.W. Sta.	$ 900,000
Install New C.W. Main and Distr. Lines	550,000
New Sewer Mains	200,000
New API Separators	550,000
Emergency C.W. Tower and Misc.	60,000
Total Required Investment	$2,260,000

TABLE 3—Cooling Tower Operating Data

ITEM	C.T. No. 1 Cells 1 & 2	C.T. No. 1 Cells 3, 4, 5,	C.T. No. 2
1. Draft, Type	Induced	Induced	Induced
2. Water Temp. to Tower, °F	110	110	120
3. Water Temp. from Tower, °F	82	82	82
4. Circulation Rate, gpm	6,000	9,000	12,000
5. Heat Duty, x 10^6 Btu/Hr.	85	127	228
6. Elev. Above Sea Level, ft.	<100	<100	<100
7. Min. Atm. Temp, °F	—20	—20	—20
8. Design Wet Bulb Temp., °F	77	77	77
9. Design Wind Vel., m.p.hr.	12	10	13
10. No. of Cells	2	3	5
11. Salt Water Analysis			
A. Chlorides, ppm		10,000—12,000	
B. pH		6.0—7.5	
C. Dissolved Solids, ppm		21,000—25,000	
D. Suspended Solids, ppm		50—550	

About the Author

Robert W. Keck is a senior engineer for The California Oil Co., Perth Amboy, N.J., where he supervises engineering design in the Manufacturing and Utilities Department (crude distillation plants and utility generation and distribution). Holder of a B.S. degree in mechanical engineering from Northeastern University, he is a registered professional engineer in New Jersey. Keck has been with California Oil since 1951.

New Japanese

Based on excess ammonia and total recycle, this new process produces crystal and prilled urea of extremely high quality

A. Kume
Mitsui & Co., New York City

TOYO KOATSU INDUSTRIES has developed a new urea manufacturing process based on total solution recycle. Crystal and prilled urea of extremely low biuret can be made with conversion efficiencies approaching 100 percent.

PROCESS DESCRIPTION

Urea Synthesis. The starting materials are liquid ammonia and purified carbon dioxide gas. CO_2 is compressed to 3,100-4,200 psi and fed directly to the autoclave as a gas introduced as a liquid. Liquid ammonia, together with recovered ammonium carbonate solution, is simultaneously fed to the autoclave by liquid pumps.

Operating conditions in the autoclave are 340-360° F and 3,100-4,200 psi. The molar ratio of NH_3 to CO_2 in the mixture fed to the autoclave is about 3.5-5. The conversion efficiency of feed CO_2 to urea in the autoclave is 57-70 percent.

Purification and Prilling of Urea. The reactor effluent is reduced in pressure by an expansion valve at the outlet of the autoclave and fed to a high pressure decomposer, and then to a low pressure decomposer. In these decomposers, excess NH_3 and unconverted carbamate are decomposed and separated.

Solution from the low pressure decomposer contains about 70 percent urea and small amounts of NH_3 and CO_2. These unconverted materials are removed in a gas separator.

Urea solution thus obtained is further concentrated in an evaporator, and impurities, such as heavy metals, are removed by a filter. The concentrated urea solution is passed through a crystallizer, a centrifuge and a dryer, yielding crystal urea of high purity.

To obtain prilled urea, crystal urea is conveyed to the top of the prilling tower, remelted, and sent to the prilling equipment in the tower.

Recovery of Unconverted NH_3 and CO_2. Separated excess NH_3 and CO_2 from the high pressure decomposer are fed to a high pressure absorber and absorbed in solutions such as ammonium carbonate, aqueous ammonia, etc., and recycled to the autoclave as recovered ammonium carbonate solution. Pure NH_3 gas from the top of the high pressure absorber is recycled after condensation in a NH_3 condenser.

Separated NH_3 and CO_2 from the low pressure decomposer are recovered in a low pressure absorber and absorbed in solution obtained from the gas separator, total solution being used as absorbing solution in the high pressure absorber.

PROCESS FEATURES

Excess Ammonia. The Toyo Koatsu process uses 50 to 150 percent excess NH_3. The synthesis pressure (3,100-4,200 psi) is higher than other conventional processes while the temperature is about the same (340-360° F). Under these conditions, corrosion in the autoclave presents no problem whatever. By using excess NH_3, the conversion ratio of CO_2 to urea is increased. The conversion ratio of NH_3 in the autoclave is almost stoichiometric. Advantages from using excess NH_3 are:

About the Author

Akira Kume is technical liaison representative in the United States for all Mitsui affiliates in the chemical industry. He was graduated from Tokyo Institute of Technology with a Masters Degree in 1938 and joined Mitsui & Co. in synthetic petroleum work. He served as a technical officer in the Japanese army in 1940 and became a consulting engineer in 1945. He became New York representative and assistant manager for Mitsui in 1951.

Urea Process

- Smaller equipment in the synthesis section
- Amount of carbamate to be decomposed in the purification system is small, resulting in smaller equipment and lower steam consumption
- Amount of carbamate to be recovered in the recovery system is small, resulting in smaller equipment
- No cooling equipment is required to maintain the temperature in the autoclave. Consequently, the construction of the autoclave is simplified
- Countermeasures to meet corrosion are simplified.

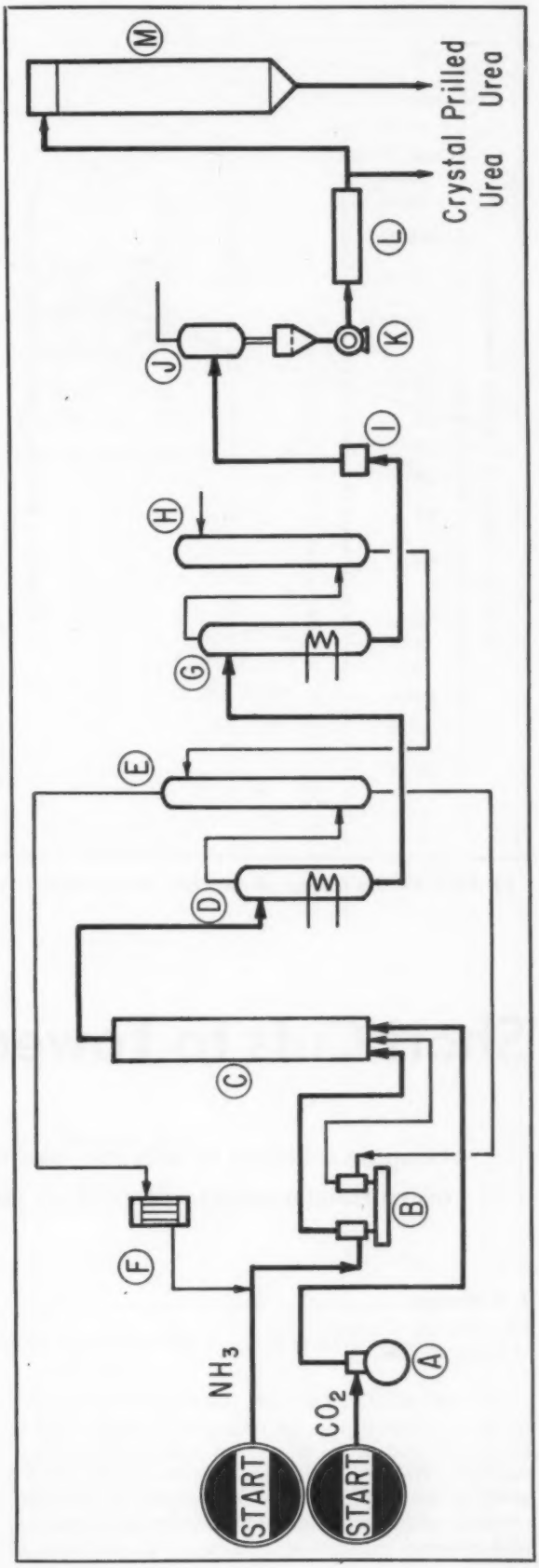
Solution Recycle. The combination of solution recycle with the use of excess ammonia results in lower construction cost and utilities consumption giving lower manufacturing costs for urea. Utilities per ton of urea are: steam, 3,200 pounds; power, 154 kwh, and cooling water, 26,400 gallons.

Product Quality. High grade product with biuret content of less than 0.3 percent in prilled urea and less than 0.1 percent in crystal urea are obtained even with total recycle.

Water content of prilled urea can be easily reduced to less than 0.2 percent. Also, no after treatment of prills is required and the hardness, particle size, etc. of the prills is not damaged.

Conversion Efficiency. Careful attention is paid to the recovery of NH_3 and CO_2. Conversion efficiencies close to 100 percent are possible. Raw material consumption, per ton of urea, are less than 1,172 pounds of ammonia and 1,522 pounds of carbon dioxide.

Corrosion and Clogging. These problems are eliminated in the new Toyo Coatsu process. # #



KEY TO FLOW DIAGRAM

A—CO_2 Compressor
B—Liquid Pumps
C—Autoclave
D—High Pressure Decomposer
E—High Pressure Absorber
F—NH_3 Condenser
G—Low Pressure Decomposer
H—Low Pressure Absorber
I—Filter
J—Evaporator
K—Centrifugal Separator
L—Dryer
M—Prilling Tower

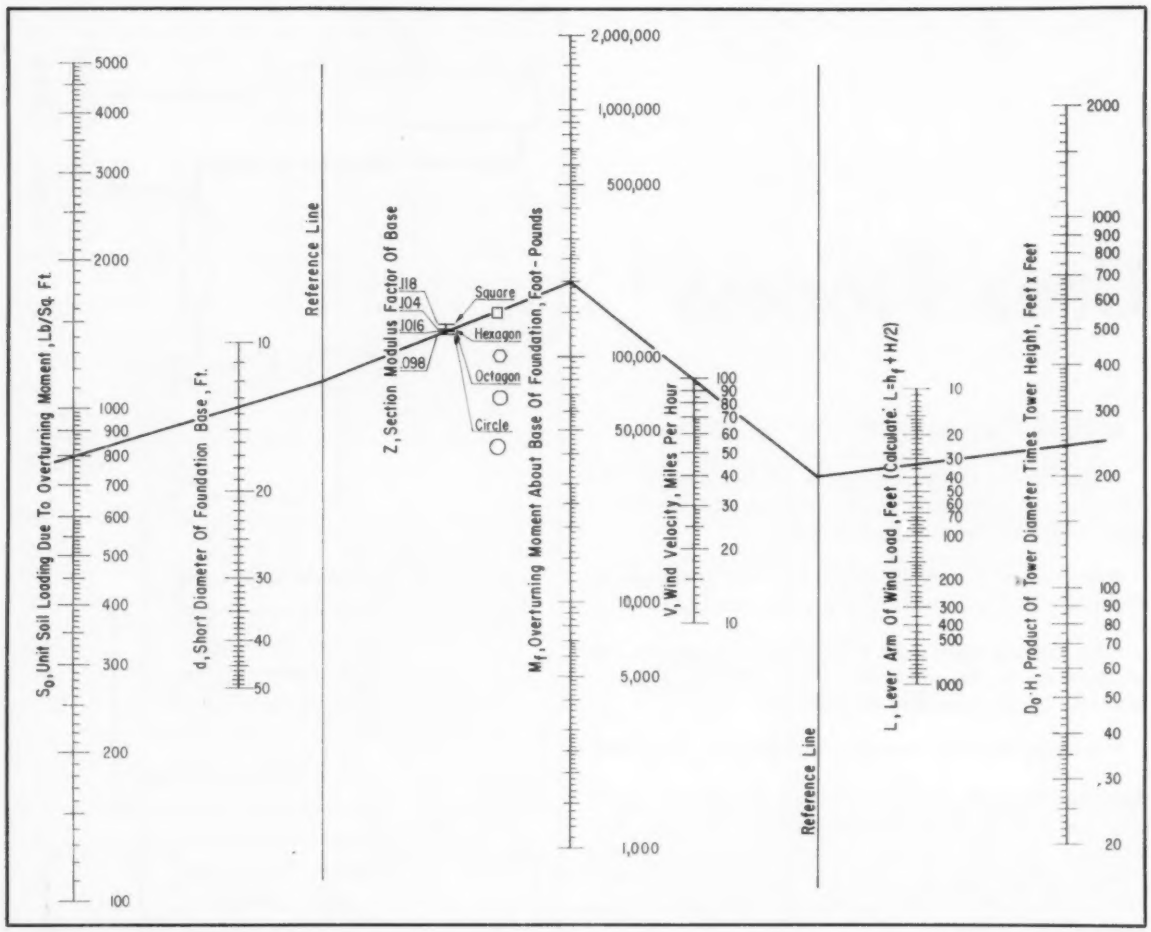

S_0, Unit Soil Loading Due To Overturning Moment, Lb/Sq. Ft.
d, Short Diameter Of Foundation Base, Ft.
Reference Line
Z, Section Modulus Factor Of Base
.118
.104
.1016
.098
Square
Hexagon
Octagon
Circle
M_f, Overturning Moment About Base Of Foundation, Foot-Pounds
V, Wind Velocity, Miles Per Hour
Reference Line
L, Lever Arm Of Wind Load, Feet (Calculate: $L=h_f+H/2$)
$D_0 \cdot H$, Product Of Tower Diameter Times Tower Height, Feet x Feet

FIGURE 1—This nomograph calculates the overturning moment and the unit soil loading in tower foundation design.

Short Cuts to Tower Foundation Design

Graphic solutions to unit soil loading and loading caused by the overturning moment will speed up your foundation calculation time

J. F. Kuong
Atlas Powder Company
Wilmington, Del.

"FOUNDATION DESIGN For Stacks and Towers" by V. O. Marshall was the subject of a special supplement published in the May 1958 issue of PETROLEUM REFINER. This article, in turn, supplements Marshall's article in that it presents two nomographs for short-cut methods to the analytical formula techniques requiring trial-and-error calculations.

In designing foundations for self-supporting towers, with respect to the supporting soil, two main considerations are taken into account: a) the unit soil loading, and b) the tower stability. These two factors must be studied. The first so that the maximum load the soil supports will not be exceeded and the second to prevent overturning of the tower by external forces, such as those caused by the wind pressure acting on the tower.

Calculations for this type of foundation requires a trial-and-error procedure. The size of the foundation is assumed. Then, the soil loading and stability are

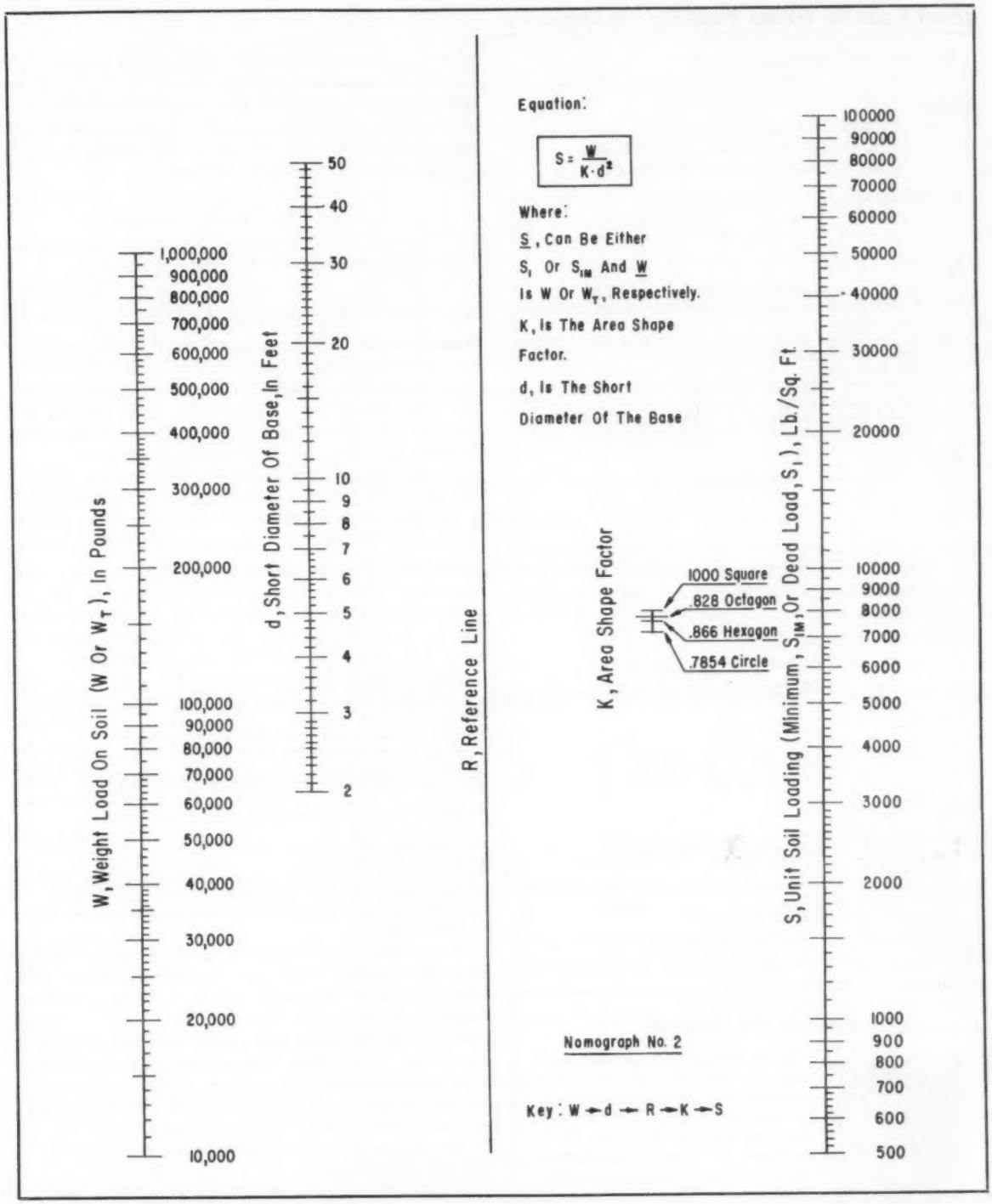


FIGURE 2—Use this nomograph to find the minimum and dead soil loading for tower foundation design.

checked and used as a criteria to determine the suitability of the foundation size originally assumed.

In estimating the maximum soil loading, two kinds of loading must be considered, namely: a) the unit soil loading due to the dead load (which includes the weight of the empty tower, appurtenances and foundation, as well as the earth fill on top of the foundation base) and, b) the unit soil loading caused by the overturning moment produced by the wind or any other lateral forces acting on the tower.

The total soil loading is, therefore,

$$S = S_1 + S_o$$

where:

S = Total soil loading, psf.
S_1 = Unit soil loading, dead load, psf.
S_o = Unit soil loading, moment, psf.

S_1 and S_o are calculated as follows:

$$S_1 = \frac{W}{a} \quad (2) \quad \text{and} \quad S_o = \frac{M_f}{Z} \quad (3)$$

where:

a, is the area of the base of the foundation, sq. ft.
M_f, Overturning moment about the base of the foundation, foot-pounds.
W, is the weight of the empty tower plus the weight of the foundation itself, including the earth fill on top of the base (minimum dead load), plus the weight of auxiliaries to include the weight of the tower contents and appurtenances, in pounds.
Z, is the section modulus of the base of the foundation which varies with the geometric shape, cu. ft.

Now, since

$$a = K\,(d)^2 \quad (4)$$

and,

$$Z = F\,(d)^3 \quad (5)$$

where d is the short diameter of the foundation base and K and F are proportionality constants for a given geometrical shape of the foundation base (octagonal, round, etc.), and since for cylindrical towers the overturning moment is given by

$$M_f = 0.0025(V)^2 \cdot D_o \cdot H \cdot L \quad (6)$$

equations (2) and (3) can be written as follows,

$$S_1 = \frac{W}{K \cdot d^2} \quad (7)$$

$$S_o = \frac{0.0025(V)^2 \cdot D_o \cdot H \cdot L}{F \cdot d^3} \quad (8)$$

Here,

V, wind velocity, mph.
D_o, diameter of tower including insulation, ft.
H, height of tower, ft.
L, lever arm of wind load, in feet, calculated as follows: $L = h_f + H/2$.
h_f, height of foundation, ft.

Furthermore, the condition of poorest stability occurs when the tower is installed by itself. In other words, when it is erected and empty and does not include auxiliaries. As explained in more detail by Marshall,[1] in calculating the stability of the tower, the maximum soil loading must be used in equation (7) as defined in this paragraph. Calling the minimum soil loading S_{1m} and W_T the minimum deadload, we have:

$$S_{1m} = \frac{W_T}{K \cdot d^2} \quad (9)$$

and the condition of a perfectly balanced system, as explained in more detail in the reference article, is

$$S_{1m} = S_o \quad (10)$$

and for an actual system S_{1m} should not be less than S_o.

Nomographs. Based on equations (7), (8) and (9), two nomographs have been prepared which reduce the time required in repeated trial-and-error calculations. The first, based on equation (8), gives directly the value of the unit soil loading due to the overturning moment, M_f, when V, D_o, H and h_f are known.

The second nomograph solves both equations (7) and (9) when W, W_T and d are known. The nomograph is the same since equations (7) and (9) differ only in the value of W which is required to calculate S_1 or S_{1m}.

Example. Consider the same example given in the Marshall article (to which reference is made for detailed calculations) and compare the solutions obtained for S_1, S_o and S_{1m} using the nomographs presented here, with those given in the original reference.

The following data are given:

Tower diameter inc. insulation, D_o = 4.5 ft.
Weight of empty tower ..... 30,000 lbs.
Weight of assumed concrete foundation volume based on octagon-shaped base ..... 63,000 lbs.
Weight of earth fill ..... 32,700 lbs.
Minimum dead load, W_T, (30,000 + 63,000 + 32,700) ..... 125,700 lbs.
Weight of auxiliaries, insulation, platforms, piping, etc., plus liquid ..... 48,500 lbs.
Total height, H, 54 ft.
Height of foundation, h_f, 6 ft.
Assumed short diameter of octagon-shaped based, d, 13.5 ft.
K, area proportionality constant for octagon base is 0.828.
F, section modulus proportionality constant for octagon-shaped base is 0.1016.

To calculate S_o, multiply $D_o \cdot H = 4.5 \cdot 54 = 243.8$. Calculate $L = 6 + 54/2 = 33$. Enter 243.8 on D_oH scale (Figure 1) and align with L = 33 on L scale to intersection with first reference line. With reference line as a pivot, align pivot point with V = 100 to obtain M_f = 200,000. Connect 200,000 on M_f scale with reference point for octagon section modulus factor and second reference line. Finally, align pivot point on second line with d = 13.5 and read S_o = 800 lbs./sq. ft. on extreme left scale. The calculated value given in the reference is 803.

To calculate S_1 (use Figure 2). Align W = 174,200 on left scale on nomograph No. 2 with d = 13.5 and reference line. Connect pivot point on reference line with octagon area factor and read S_1 = 1150 lbs./sq. ft. The reference article gives S_1 = 1155.

To calculate S_{1m} (use Figure 2). Repeat procedure outlined just above except use W_T = 125,700 instead of W = 174,200, and read S_{1m} = 830. This value compares with 830 as given in the reference.

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[1] Marshall, V. O., Foundation Design Handbook for Stocks and Towers, Petroleum Refiner, 37, No. 5, Supplement (1958).

About the Author

J. F. Kuong is a process engineer for Atlas Powder Co., Wilmington, Del., where he works in process improvement, trouble shooting and cost reduction. He is currently in charge of a technical section doing technical-economic studies, process improvement work and technical support for line supervision. Holder of a B.S. degree in chemical engineering from the University of San Marcos, Peru, and M.S. degree in chemical engineering from the University of Pennsylvania, he has been with Atlas since 1954. Kuong worked in the Technical Department, Atlas Point Plant until 1956, when he became technical assistant to the production superintendent. Kuong has been a process engineer since 1957.

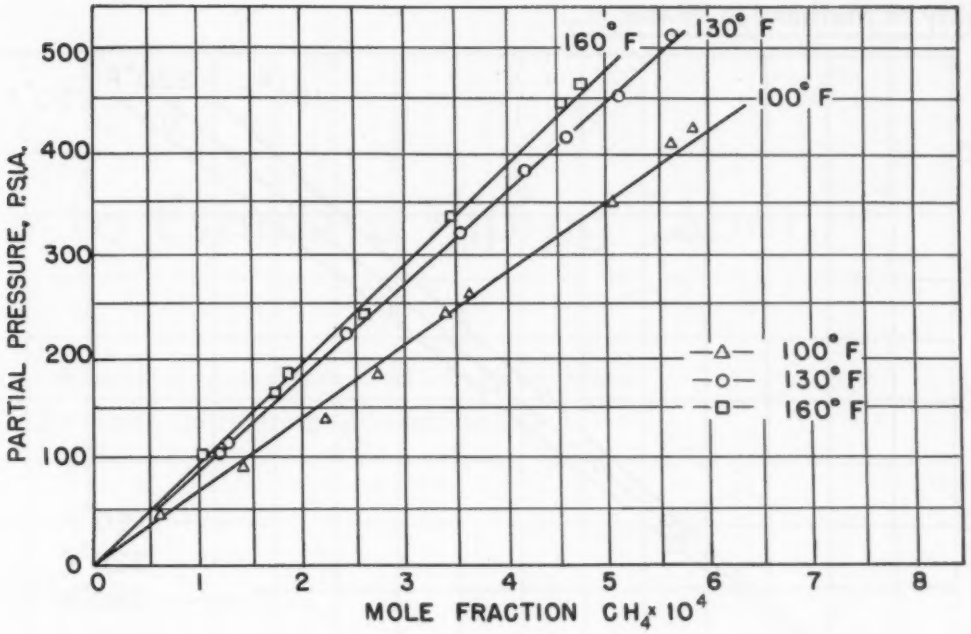

FIGURE 1—Partial pressure of methane vs. concentration in region of decreasing solubility.

Solubility of Methane in Water

Jerry E. Davis* and John J. McKetta
The University of Texas, Austin

MOST OF the work on the solubility of methane in water has been at either extremely high pressures[4] or at atmospheric pressure.[5] This investigation is a study of the solubility of methane in water at pressures to 500 psia at temperatures from 100° to 250° F.

Experimental Techniques. The equilibrium equipment is similar to that used by Brooks and McKetta,[2] and Culberson, Horn, and McKetta.[3] The analytical train is similar to that described by Azarnoosh and McKetta.[1]

Materials Used. The water was degassed, distilled water. The methane was Phillips Pure Grade, 99 percent minimum purity.

Discussion of Results. The experimentally determined solubility of methane in water is shown in Table 1. A plot of the partial pressure of methane in the vapor vs. mole fraction of dissolved methane yields a straight line, therefore methane follows Henry's Law at the pressures of this investigation. For the sake of clarity these data are presented on separate partial pressure-composition diagrams. Figure 1 shows the region of decreasing solubility, and Figure 2 shows the region of increasing solu-

*Present address: Procter & Gamble Co., Ivorydale, Ohio

TABLE 1—Experimental Data
Concentration of Methane in Water Rich Liquid

100° F		130° F		160° F		190° F		220° F		250° F	
Total Pressure psia	Mole Frac. Methane x 10^4	Total Pressure psia	Mole Frac. Methane x 10^4	Total Pressure psia	Mole Frac. Methane x 10^4	Total Pressure psia	Mole Frac. Methane x 10^4	Total Pressure psia	Mole Frac. Methane x 10^4	Total Pressure psia	Mole Frac. Methane x 10^4
51	0.64	113	1.28	112	1.05	114	1.26	75	0.64	101	0.96
98	1.48	124	1.28	170	1.76	136	1.46	119	1.18	212	2.26
145	2.26	228	2.46	190	1.88	168	1.73	216	2.26	333	3.74
188	2.78	326	3.59	249	2.65	200	2.13	277	3.00	410	4.60
249	3.44	389	4.22	343	3.50	219	2.31	370	4.21	469	5.23
269	3.68	421	4.63	455	4.59	260	2.89	415	4.71	557	6.35
356	5.09	461	5.14	474	4.77	313	3.31	474	5.30	...	...
415	5.66	521	5.64	...	...	383	3.97	...	...	...	...
430	5.88	...	...	...	...	537	5.70	...	...	...	...

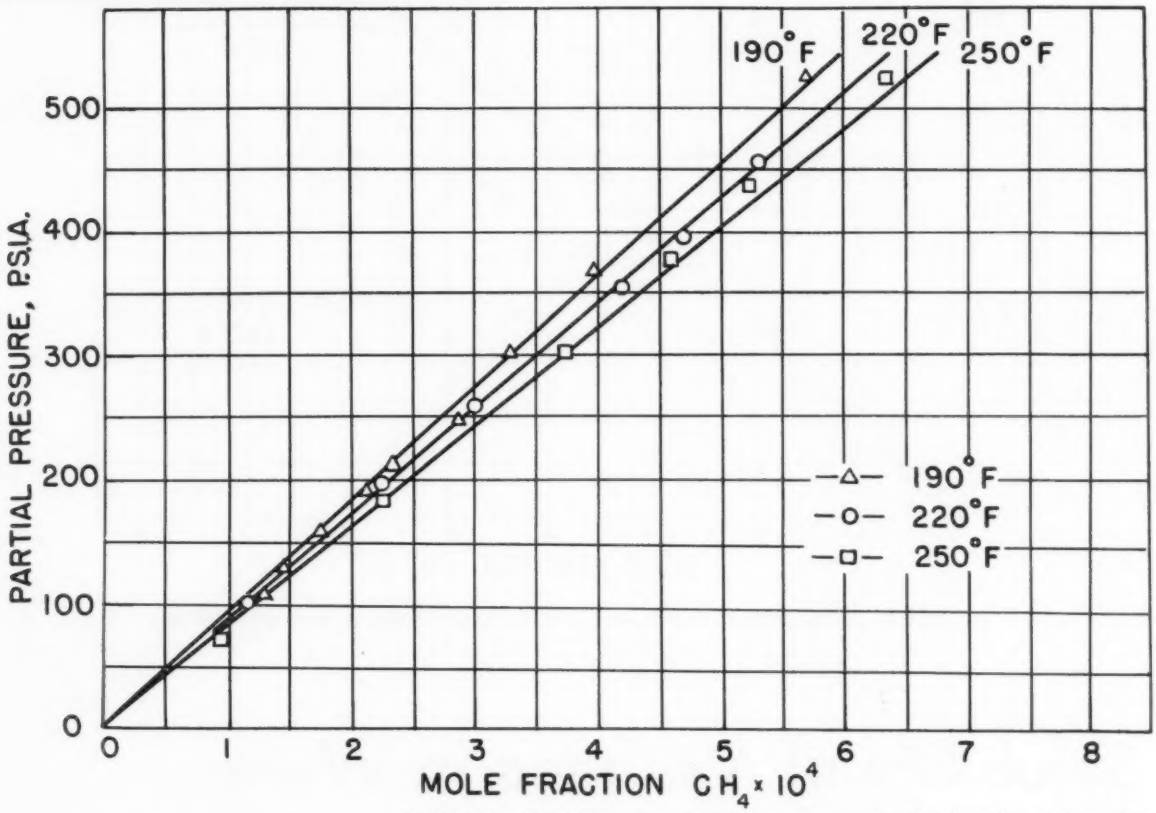

FIGURE 2—Partial pressure of methane vs. concentration in region of increasing solubility.

TABLE 2—Smoothed Data
Concentration of Methane in Water Rich Liquid Phase in Mole Fraction x 10^4

Pressure, psia	TEMPERATURE, °F.					
	100°	130°	160°	190°	220°	250°
14.7	0.20	0.13	0.10	0.05	....	....
50	0.70	0.53	0.46	0.44	0.39	0.24
100	1.39	1.08	0.98	0.99	0.98	0.85
150	2.09	1.63	1.49	1.53	1.57	1.46
200	2.79	2.19	2.01	2.09	2.16	2.07
250	3.49	2.74	2.53	2.64	2.75	2.68
300	4.18	3.29	3.04	3.19	3.34	3.29
350	4.88	3.87	3.56	3.74	3.93	3.90
400	5.58	4.40	4.07	4.29	4.52	4.51
450	6.27	4.95	4.49	4.84	5.11	5.12
500	6.97	5.50	5.10	5.39	5.70	5.73

bility. The smoothed data taken from these plots are presented in Table.[2] These data are also presented on a temperature-composition diagram in Figure 3. This figure shows a minimum solubility at about 160° F.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contribution of the pure grade methane by the Phillips Petroleum Company. This study was made possible by a grant from the National Science Foundation.

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[3] Culberson, O. L., Horn, A. B., and McKetta, J. J. Trans. Am. Inst. Mining Met. Engrs., Petrol. Div., 189, 1, (1950).
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[5] Winkler, L. W. Ber 34, 1408, (1901).

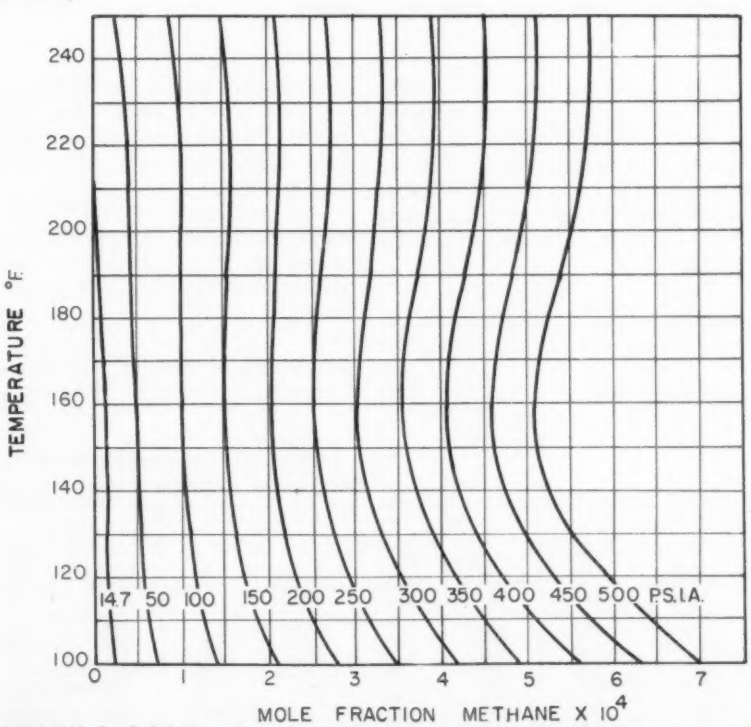


FIGURE 3—Solubility of methane in water as a function of temperature and pressure.

How to Estimate Piping Labor

Use these tables to estimate field labor man-hours for handling, fabricating and erecting pipe

O. R. Roberts
Stearns-Roger Manufacturing Co., Denver

HERE IS A SET of tables of piping labor units and a system for using them to estimate fabrication and installation labor. This system can be used to estimate labor for a single line addition consisting of a few items or a large process unit with several tons of pipe, valves and fittings.

The system is intended for estimating field fabricated and installed piping. It applies to refinery and petrochemical, or similar process units. However, it can be adapted to other types of work such as the example included.

A bill of material for the complete system to be estimated is required. Enter the units opposite the item quantities, extend and total for the basic hours.

Basic hours is a relative labor evaluation of the materials to be fabricated and installed. Basic hours can be used for comparing estimated work with performance records.

The code number as shown on the example bill of material, is for electric machine accounting. The labor units can be punched on the EMA system, along with the code numbers, for accounting the basic hours. The machine method saves time on large jobs. However, the work can be done by clerical labor where machines are not available.

Basic Hours multiplied by the Job Factor, which is determined by the estimator, equals the estimated hours required to fabricate and install the piping.

The accuracy of the job factor is dependent upon the experience, judgment and skill of the estimator. He should make a complete analysis of the job for size, arrangement, quality of labor available, supervision, work schedule, testing, weather and other conditions that might affect labor. The result of this job analysis is the job factor. Examples are included later.

The tables of units represent a standard condition or "norm" of field production. They are indicative of competent mechanics, sufficient tools, efficient management, normal work schedule and other favorable conditions. The estimator must determine the job factor that will adjust the standard units to actual job conditions.

Here are some examples of adjustments to determine the job factor for the example bill of material which has 543.9 basic hours.

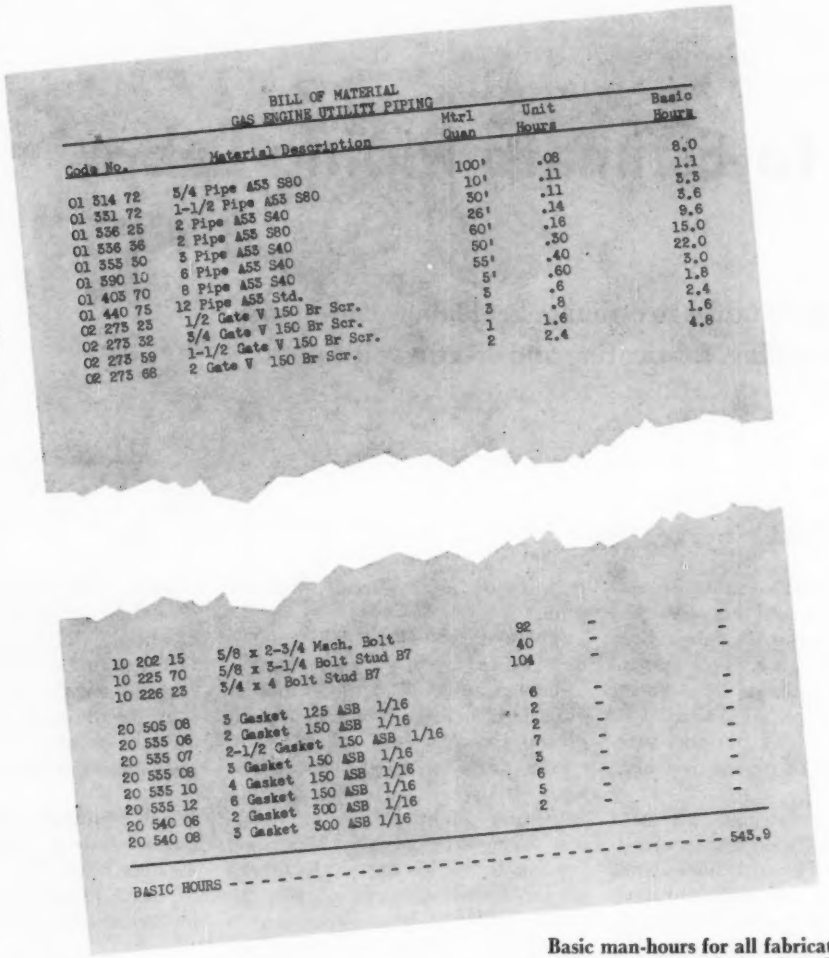
Testing. The tables do not include testing. Ordinary testing with air or water, adjustment of packing glands and follow up on bolted joints will run approximately 3 to 7 percent of the basic hours. This will vary with materials, testing specs and inspectors; for our example say—4 percent.

Supervision. The tables include a foreman for each crew of nine mechanics. The general foreman time should be added as required for your conditions. The example of engine utility piping is part of a large project and must carry a proportionate share of the general foreman hours. Say one general foreman with four crews or approximately—3 percent.

Work Schedule. The tables include normal fatigue and lost time for a 40 hour week. For our example let us use a 50 hour week and add for inefficiency say—2 percent.

Type of Project. The tables are based on average refinery and petrochemical plant process units with pumps, exchangers and other equipment installed outside at grade elevation and with piping run on overhead supports. Piping in high structures, crowded buildings, in limited access areas, around existing equipment or with other limiting conditions would require an additional factor for their portion of the labor. For the example of 543.9 basic hours of relatively simple engine utility piping say no additional labor factor required—0 percent.

Quality of Labor. Some projects produce more work per man-hour than others. This has been referred to as employee-job psychology or the human element. It is subject to the changing times such as war and peace, recession and boom and has a wide range—as much as 25 per-



BILL OF MATERIAL
GAS ENGINE UTILITY PIPING

Code No.	Material Description	Mtrl Quan	Unit Hours	Basic Hours
01 314 72	5/4 Pipe A53 S80	100'	.08	8.0
01 331 72	1-1/2 Pipe A53 S80	10'	.11	1.1
01 336 25	2 Pipe A53 S40	30'	.11	3.3
01 336 36	2 Pipe A53 S80	26'	.14	3.6
01 355 30	3 Pipe A53 S40	60'	.16	9.6
01 390 10	6 Pipe A53 S40	50'	.30	15.0
01 403 70	8 Pipe A53 S40	55'	.40	22.0
01 440 75	12 Pipe A53 Std.	5'	.60	3.0
02 273 25	1/2 Gate V 150 Br Scr.	3	.6	1.8
02 273 32	3/4 Gate V 150 Br Scr.	3	.8	2.4
02 273 59	1-1/2 Gate V 150 Br Scr.	1	1.6	1.6
02 273 68	2 Gate V 150 Br Scr.	2	2.4	4.8
10 202 15	5/8 x 2-3/4 Mach. Bolt	92	-	-
10 225 70	5/8 x 3-1/4 Bolt Stud B7	40	-	-
10 226 23	3/4 x 4 Bolt Stud B7	104	-	-
20 505 08	3 Gasket 125 ASB 1/16	6	-	-
20 535 06	2 Gasket 150 ASB 1/16	2	-	-
20 535 07	2-1/2 Gasket 150 ASB 1/16	2	-	-
20 535 08	3 Gasket 150 ASB 1/16	7	-	-
20 535 10	4 Gasket 150 ASB 1/16	3	-	-
20 535 12	6 Gasket 150 ASB 1/16	6	-	-
20 540 06	2 Gasket 300 ASB 1/16	5	-	-
20 540 08	3 Gasket 300 ASB 1/16	2	-	-
BASIC HOURS				543.9

Basic man-hours for all fabrication and erection are tabulated on the bill of materials.

cent and more in some extreme cases.

Great activity with high employment in the project area will influence productivity of labor; also company reputation and labor relations have great influence.

The tables are based on average conditions—no extreme in either direction.

For the example assume an area of low activity with low employment. We have experienced good labor relations in this area and our past performance records show slightly above average. The engine utility piping is part of a well staffed project with materials available. We can foresee no possible difficulty in work performance. Let us say our over-all labor quality should be above average by (this is a negative factor to basic hours)—10 percent (—).

Weather. The tables are based on favorable weather. Extreme cold, heat, rain, snow or wind will affect the basic hours. Consult the nearest weather bureau office and check your experience in the area.

For the example let us say we expect the work to be scheduled for the winter season. The area is subject to some extreme cold. Say about half the work will be affected by 10 percent inefficiency or an over-all factor of say—5 percent.

Any other foreseeable conditions that will affect the basic hours should be considered in the job factor.

Our total job factor is a plus—4 percent.

Estimated Hours = Basic Hours × Job Factor.

Estimated Hours = 543.9 × 104 percent = 571 Man Hours.

Estimated hours times the average wage rate equals the direct labor cost estimated to fabricate and install the piping. The estimated hours include general foremen, foremen, welders, fitters, helpers, truck drivers, crane operators and other direct labor required to do the job.

The labor unit tables for separate operations of welding, flange joints, screw joints and stress relieving are to be used for estimating any special operations not accounted for on the bill of material. An example would be for extra welds in long runs of

straight pipe outside the process area.

Any hours accumulated for these special operations should be added to the basic hours from the bill of material.

Notes on the table of butt welds refer to preheat, X-ray and some materials other than carbon steel. These kinds of work are usually experienced in the more critical piping projects. Therefore, the unit tables must be implemented with wide experience for this level of piping estimate.

Summary. Labor Units are the estimator's tools, and standards for evaluating the labor in any project. With these evaluating units the relation between performance records and estimated work can be determined.

The tables can also be used for making progress reports on piping projects—percent completed, performance to date and man hours to complete.

These or other tables of units must be checked against your own job performance data before they can be used for estimating new work. They must be "zeroed" in for your standard or "norm" of production.

This can be done by making some check estimates with the bills of material from some recently completed jobs. Compare the estimated hours with the actual hours used on the jobs. This will give you some idea of what job factor is required for your standard or norm of production.

These tables are offered to those who do not already have a set of their own tables in operation. We hope they will be of help to you in starting your own systematic process of estimating piping labor.

About the Author

O. R. Roberts has been with Stearns-Roger Manufacturing Co. since 1953 as a mechanical engineer and estimator for the Oil and Gas Division. For six years before that he was with a major oil company in project construction and as assistant to the technical director of a refinery. Roberts has more than 15 years of heavy experience in engineering, estimating and construction of refineries, petrochemical and other process plants, with some outstanding companies. He is a registered professional engineer in Colorado.

Weld Tees—Man-Hours Each—Field Labor*

SIZE	Std. Wt.	Ex. Hv.	Sch. 10	20	30	40	60	80	100	120	140	160
¾	2.4	2.7	....	....	....	2.4	....	2.7	....	....	....	3.3
1	2.8	3.3	....	....	....	2.8	....	3.3	....	....	....	3.9
1¼	3.3	3.9	....	....	....	3.3	....	3.9	....	....	....	4.2
1½	3.6	4.2	....	....	....	3.6	....	4.2	....	....	....	5.1
2	4.2	5.1	....	....	....	4.2	....	5.1	....	....	....	6.0
2½	5.4	6.3	....	....	....	5.4	....	6.3	....	....	....	7.2
3	6.0	7.5	....	....	....	6.0	....	7.5	....	....	....	8.7
4	7.5	9.0	....	....	....	7.5	....	9.0	....	10.5	....	12.0
6	10.2	13.5	....	....	....	10.2	....	13.5	....	16.5	....	19.2
8	13.8	18.6	....	11.7	12.3	13.8	15.9	18.6	21.0	24.0	28.8	31.5
10	17.1	22.2	....	13.5	15.0	17.1	22.2	25.2	30.6	37.5	43.5	48.3
12	19.8	25.5	....	15.0	18.0	21.0	28.2	33.6	44.7	52.8	58.8	67.5
14	21.0	28.2	15.9	18.6	21 3	23.7	32.4	44.4	54.9	63.3	71.4	80.1
16	23.7	31.5	17.7	20.7	23.7	31.5	45.0	57.3	69.3	81.3	95.1	113.4
18	26.4	35.7	19.2	22.8	30.0	39.6	58.2	71.7	89.1	105.6	127.5	144.4
20	29.1	39.3	20.7	29.1	39.3	46.5	69.9	89.1	110.7	139.5	163.8	186.6
24	34.2	47.4	24.0	34.2	53.4	65.7	102.9	130.8	178.5	215.1	249.3	292.8

* These units include all labor to receive, store, handle thru fabrication, fit, weld, erect and align on pipe racks.

Weld Reducers—Man-Hours Each—Field Labor*

SIZE	Std. Wt.	Ex. Hv.	Sch. 10	20	30	40	60	80	100	120	140	160
¾ x ½	1.4	1.5	....	....	....	1.4	....	1.5	....	....	....	2.0
1 x ¾	1.8	2.0	....	....	....	1.8	....	2.0	....	....	....	2.4
1¼ x 1	2.0	2.4	....	....	....	2.0	....	2.4	....	....	....	2.7
1½ x 1¼	2.3	2.7	....	....	....	2.3	....	2.7	....	....	....	3.1
2 x 1½	2.6	3.1	....	....	....	2.6	....	3.1	....	....	....	3.7
2½ x 2	3.2	3.8	....	....	....	3.2	....	3.8	....	....	....	4.4
3 x 2½	3.8	4.6	....	....	....	3.8	....	4.6	....	....	....	5.3
4 x 3	4.5	5.5	....	....	....	4.5	....	5.5	....	6.4	....	6.9
6 x 4	5.9	7.5	....	....	....	5.9	....	7.5	....	9.0	....	10.4

* These units include all labor to receive, store, handle thru fabrication, fit, weld, erect and align on pipe racks.

Tables continued on next page

Weld Reducers—Man-Hours Each—Field Labor* (Continued)

SIZE	Std. Wt.	Ex. Hv.	Sch. 10	20	30	40	60	80	100	120	140	160
8 x 6	8.0	10.7	....	7.3	7.5	8.0	9.8	10.7	12.5	13.5	16.0	16.9
10 x 8	10.3	13.6	....	8.4	9.1	10.3	12.7	14.6	17.2	20.5	24.1	26.6
12 x 10	12.3	15.9	....	9.5	11.0	12.7	16.8	19.6	25.1	30.1	34.1	38.6
14 x 12	13.6	17.9	10.3	11.2	13.1	14.9	20.2	26.0	33.2	38.7	43.4	49.2
16 x 14	14.9	19.9	11.2	13.1	15.0	18.4	25.8	33.9	41.4	48.2	55.5	64.5
18 x 16	16.7	22.4	12.3	14.5	17.9	23.7	34.4	43.0	52.8	62.3	74.2	86.6
20 x 18	18.5	25.0	13.3	17.3	23.1	28.7	42.7	53.6	66.6	81.7	97.1	111.0
24 x 20	21.1	28.9	14.9	21.1	30.9	37.4	57.6	73.3	96.4	118.2	137.7	160.0

* These units include all labor to receive, store, handle thru fabrication, fit, weld, erect and align on pipe racks.

Flanges—Weld Neck Type—Man-Hours Each—Field Labor*

RATING BORE	150 Std.	300 Std.	300 Ex. Hv.	300 80	400 Std.	600 Std.	600 Ex. Hv.	600 80	1500 80	1500 160	2500 160
Size											
¾	1.4	1.5	1.6	1.6	....	1.5	1.6	1.6	1.9	2.1	2.1
1	1.7	1.8	1.9	1.9	....	1.8	1.9	1.9	2.2	2.4	2.4
1¼	1.8	1.9	2.1	2.1	....	1.9	2.1	2.1	2.4	2.5	2.7
1½	2.0	2.1	2.3	2.3	....	2.1	2.3	2.3	2.7	3.0	3.2
2	2.2	2.5	2.8	2.8	....	2.6	2.9	2.9	3.4	3.7	4.5
2½	2.6	3.2	3.5	3.5	....	3.3	3.6	3.6	4.3	4.6	4.9
3	2.9	3.4	3.9	3.9	....	3.5	4.0	4.0	5.0	5.4	5.9
4	3.6	3.9	4.4	4.4	4.2	4.2	4.7	4.7	6.0	7.0	8.0
6	4.7	5.4	6.5	6.5	5.9	6.4	7.5	7.5	9.5	11.4	12.9
8	5.9	7.1	8.7	8.7	7.6	8.1	9.7	9.7	12.6	16.9	20.1
10	7.9	9.2	10.9	11.9	9.7	10.5	12.2	13.2	16.4	24.1	30.1
12	8.8	10.6	12.5	15.2	12.1	12.6	14.5	17.2	23.2	34.5	39.5
14	9.6	12.0	14.4	19.8	13.0	14.2	16.6	22.0	....	....	....
16	11.4	13.9	16.5	25.1	14.9	15.9	18.5	27.1	....	....	....
18	12.8	15.3	18.4	30.4	16.8	17.8	20.9	32.9	....	....	....
20	14.2	16.7	20.1	36.7	18.7	20.7	24.1	40.7	....	....	....
24	16.9	20.4	24.8	52.6	23.4	25.4	29.8	57.6	....	....	....

* These units include all labor to receive, store, handle thru fabrication, fit, weld, erect and align on pipe racks, install gasket and bolt up service tight.

Butt Welds—Man-Hours Each—Field Labor

SIZE	Std. Wt.	Ex. Hv.	Sch. 10	20	30	40	60	80	100	120	140	160
¾	.80	.90	....	....	....	.80	....	.90	....	....	....	1.10
1	.95	1.10	....	....	....	.95	....	1.10	....	....	....	1.30
1¼	1.10	1.30	....	....	....	1.10	....	1.30	....	....	....	1.40
1½	1.2	1.4	....	....	....	1.2	....	1.4	....	....	....	1.7
2	1.4	1.7	....	....	....	1.4	....	1.7	....	....	....	2.0
2½	1.8	2.1	....	....	....	1.8	....	2.1	....	....	....	2.4
3	2.0	2.5	....	....	....	2.0	....	2.5	....	....	....	2.9
4	2.5	3.0	....	....	....	2.5	....	3.0	....	3.5	....	4.0
6	3.4	4.5	....	....	....	3.4	....	4.5	....	5.5	....	6.4
8	4.6	6.2	....	3.9	4.1	4.6	5.3	6.2	7.0	8.0	9.6	10.5
10	5.7	7.4	....	4.5	5.0	5.7	7.4	8.4	10.2	12.5	14.5	16.1
12	6.6	8.5	....	5.0	6.0	7.0	9.4	11.2	14.9	17.6	19.6	22.5
14	7.0	9.4	5.3	6.2	7.1	7.9	10.8	14.8	18.3	21.1	23.8	26.7
16	7.9	10.5	5.9	6.9	7.9	10.5	15.0	19.1	23.1	27.1	31.7	37.8
18	8.8	11.9	6.4	7.6	10.0	13.2	19.4	23.9	29.7	35.2	42.5	48.8
20	9.7	13.1	6.9	9.7	13.1	15.5	23.3	29.7	36.9	46.5	54.6	62.2
42	11.4	15.8	8.0	11.4	17.8	21.9	34.3	43.6	59.5	71.7	83.1	97.6

These units do **not** include preheat, stress relieve or X-ray.
For mitre welds add 50% to these units.
For 5% chrome, 18-8 stainless type 304, 316 and 347, brass, aluminum and monel piping add approximately 100% to these units.

Handle Pipe—Man-Hours Per Lineal Foot—Field Labor*

PIPE SIZE	Std. Wt.	Ex. Hv.	Sch. 10	20	30	40	60	80	100	120	140	160
¾	.07	.08	....	....	....	.07	....	.08	....	....	....	.09
1	.08	.09	....	....	....	.08	....	.09	....	....	....	.10
1¼	.09	.10	....	....	....	.09	....	.10	....	....	....	.11
1½	.10	.11	....	....	....	.10	....	.11	....	....	....	.13
2	.11	.14	....	....	....	.11	....	.14	....	....	....	.16
2½	.14	.16	....	....	....	.14	....	.16	....	....	....	.20
3	.16	.20	....	....	....	.16	....	.20	....	....	....	.25
4	.20	.25	....	....	....	.20	....	.25	....	.30	....	.33
6	.30	.40	....	....	....	.30	....	.40	....	.45	....	.55
8	.40	.50	....	.33	.36	.40	.46	.50	.60	.70	.75	.80
10	.50	.65	....	.40	.45	.50	.65	.70	.80	.90	1.00	1.10
12	.60	.70	....	.44	.55	.60	.75	.90	1.00	1.15	1.25	1.40
14	.65	.78	.48	.55	.65	.70	.88	1.00	1.20	1.30	1.50	1.60
16	.70	.85	.50	.60	.70	.85	1.00	1.25	1.45	1.60	1.80	2.00
18	.75	.90	.55	.66	.85	1.00	1.25	1.50	1.70	2.00	2.10	2.40
20	.80	1.00	.60	.80	1.00	1.15	1.40	1.70	2.00	2.20	2.50	2.75
24	.95	1.15	.70	.95	1.25	1.50	1.90	2.30	2.60	2.75	3.00	3.50

* These units include all labor to receive, store, handle thru fabrication, erect and align on pipe racks ready for bolting or welding in place. Does NOT include any bolting or welding—these operations are accounted for in flanges and fittings.

Weld Ells—Man-Hours Each—Field Labor*

SIZE	Std. Wt.	Ex. Hv.	Sch. 10	20	30	40	60	80	100	120	140	160
¾	1.6	2.7	....	....	....	1.6	....	2.7	....	....	....	2.2
1	1.9	2.2	....	....	....	1.9	....	2.2	....	....	....	2.6
1¼	2.2	2.6	....	....	....	2.2	....	2.6	....	....	....	2.8
1½	2.4	2.8	....	....	....	2.4	....	2.8	....	....	....	3.4
2	2.8	3.4	....	....	....	2.8	....	3.4	....	....	....	4.0
2½	3.6	4.2	....	....	....	3.6	....	4.2	....	....	....	4.8
3	4.0	5.0	....	....	....	4.0	....	5.0	....	....	....	5.8
4	5.0	6.0	....	....	....	5.0	....	6.0	....	7.0	....	8.0
6	6.8	9.0	....	....	....	6.8	....	9.0	....	11.0	....	12.8
8	9.2	12.4	....	7.8	8.2	9.2	10.6	12.4	14.0	16.0	19.2	21.0
10	11.4	14.8	....	9.0	10.0	11.4	14.8	16.8	20.4	25.0	29.0	32.2
12	13.2	17.0	....	10.0	12.0	14.0	18.0	22.4	29.8	35.2	39.2	45.0
14	14.0	18.8	10.6	12.4	14.2	15.8	21.6	29.6	36.6	42.2	47.6	53.4
16	15.8	21.0	11.8	13.8	15.8	21.0	30.0	38.2	46.2	54.2	63.4	75.6
18	17.6	23.8	12.8	15.2	20.0	26.4	38.8	47.8	59.4	70.4	85.0	97.6
20	19.4	26.2	13.8	19.4	26.2	31.0	46.6	59.4	73.8	93.0	109.2	124.4
24	22.8	31.6	16.0	22.8	35.6	43.8	68.6	87.2	119.0	143.4	166.2	195.2

* These units include all labor to receive, store, handle thru fabrication, fit, weld, erect and align on pipe racks.

Screw Fittings (Including Valves) — Man-Hours Each—Field Labor**

SIZE	M.I.		F.S.	
	TEE	*Other	TEE	*Other
½	.9	.6	1.2	.8
¾	1.2	.8	1.8	1.2
1	1.5	1.0	2.4	1.6
1¼	1.8	1.2	3.0	2.0
1½	2.4	1.6	4.2	2.8
2	3.6	2.4	6.0	4.0
2½	4.5	3.0	..	..

M.I. —Malleable Iron Fittings with Std. Wt. Pipe.
F.S. —Foged Steel Fittings with Ex. Hv. Pipe.
* —Elbows, Unions and Valves.

** These units include all labor to receive, store, handle, cut, thread, fit and make up service tight in a system of screwed piping when the labor for "Handling Pipe" is added.

Screw Joints—Man-Hours Each—Field Labor

PIPE SIZE	M.I.	Steel
½	.30	.40
¾	.40	.60
1	.50	.80
1¼	.60	1.00
1½	.80	1.40
2	1.20	2.00
2½	1.50	....

M.I.—Malleable Iron Fittings and Std. Wt. Pipe.
Steel—Forged Steel Fittings and Ex. Heavy Pipe.

MATERIAL FACTOR:

Chrome Moly	Add 5%
Stainless Steel 18-8	Add 10%
Brass & Copper	Add 0%

Tables concluded on next page

How to Estimate Piping Labor . . .

Handle Flanged Valves—Man-Hours Each—Field Labor*

SIZE	125	150	300	400	600	900	1500
¾	....	.3	....	....	....	....	....
1	....	.4	....	....	....	....	....
1¼	....	.5	....	....	....	....	....
1½	.5	.6	.7	....	.8	....	1.2
2	.6	.7	.8	....	1.0	....	1.5
2½	.7	.8	1.0	....	1.2	....	1.9
3	.8	1.0	1.2	....	1.5	1.9	2.4
4	1.0	1.3	1.5	2.0	2.3	2.7	3.7
6	1.5	1.7	2.6	3.2	4.2	5.0	7.0
8	2.0	2.5	3.8	5.0	6.5	7.5	11.0
10	3.0	3.5	5.2	7.0	8.5	11.0	16.0
12	4.0	4.5	7.5	10.0	12.0	16.0	24.0
14	5.0	6.0	10.0	12.0	15.0	20.0	35.0
16	6.0	7.0	13.0	16.0	18.0	28.0	....
18	7.5	10.0	16.0	20.0	30.0	37.0	....
20	9.0	12.0	20.0	25.0	40.0	....	....
24	15.0	17.0	30.0	38.0	50.0	....	....

* These units include all labor to receive, store, erect and align on pipe racks ready for bolting up. They do NOT include bolting up—this operation is accounted for in flanges.

Stress Relieving Butt Welds—Man-Hours Each—Field Labor

SIZE	Std. Wt.	Ex. Hv.	Sch. 10	20	30	40	60	80	100	120	140	160
1½	2.0	2.0	....	....	....	2.0	....	2.0	....	....	....	2.2
2	2.0	2.2	....	....	....	2.0	....	2.2	....	....	....	2.5
2½	2.3	2.5	....	....	....	2.3	....	2.5	....	....	....	2.7
3	2.5	2.7	....	....	....	2.5	....	2.7	....	....	....	3.0
4	2.7	3.0	....	....	....	2.7	....	3.0	....	3.3	....	3.5
6	3.3	4.0	....	....	....	3.3	....	4.0	....	4.2	....	4.6
8	3.8	4.5	....	3.5	3.6	3.8	4.1	4.5	4.8	5.2	5.4	5.6
10	4.4	5.0	....	3.8	4.1	4.4	5.0	5.3	5.7	6.1	6.5	6.8
12	4.7	5.3	....	4.0	4.5	4.9	5.6	6.0	6.6	7.0	7.4	8.0
14	5.0	5.6	4.2	4.6	5.0	5.2	6.0	6.6	7.2	7.8	8.2	8.8
16	5.2	5.9	4.5	4.9	5.2	5.9	6.7	7.4	8.0	8.8	9.5	10.0
18	5.5	6.2	4.6	5.2	5.8	6.5	7.5	8.2	9.0	9.8	10.5	11.0
20	5.8	6.5	4.8	5.8	6.5	7.0	8.0	9.0	10.0	11.0	11.5	12.0
24	6.3	7.0	5.2	6.3	7.5	8.2	9.8	11.0	12.0	13.0	14.0	15.0

The ASA piping code requires stress relieving for welds in carbon steel when pipe thickness is ¾" or more (below bold line)

Flanged Joints—Man-Hours Each—Field Labor

SIZE	150	300	400	600	900	1500	2500
¾	.6	.7	....	.7	....	1.0	1.0
1	.7	.8	....	.8	....	1.1	1.1
1¼	.7	.8	....	.8	....	1.1	1.3
1½	.8	.9	....	.9	....	1.3	1.5
2	.8	1.1	....	1.2	....	1.7	2.3
2½	.8	1.4	....	1.5	....	2.2	2.5
3	.9	1.4	....	1.5	1.7	2.5	3.0
4	1.1	1.4	1.7	1.7	2.5	3.0	4.0
6	1.3	2.0	2.5	3.0	3.5	5.0	6.5
8	1.3	2.5	3.0	3.5	4.8	6.4	9.6
10	2.2	3.5	4.0	4.8	5.5	8.0	14.0
12	2.2	4.0	5.5	6.0	7.2	12.0	17.0
14	2.6	5.0	6.0	7.2	8.5	....	....
16	3.5	6.0	7.0	8.0	9.8	....	....
18	4.0	6.5	8.0	9.0	12.0	....	....
20	4.5	7.0	9.0	11.0	14.0	....	....
24	5.5	9.0	12.0	14.0	20.0	....	....

##

Graphs Find Vessel Drain Time

If you need to make quick estimates, use these nomographs to find drain time on vertical and horizontal tanks through orifices or pipe

W. A. Rostafinski
Arthur G. McKee & Co.
Cleveland

THE TIME REQUIRED to drain a tank by gravity must oftentimes be estimated. The well known Torricelli formula, $v = \sqrt{2gh}$, as such, cannot be applied because the acting head is a function of time; i.e., the liquid level decreases as time elapses, and consequently the outflow velocity decreases continuously although not necessarily uniformly, the rate of decrease being a function of the shape of the tank.

The problem may be quite complex when the flow through a simple orifice is considered, and becomes even more involved when flow is through a pipe. The time required to drain an atmospheric tank by gravity is a function of:

- The fluid properties
- The tank shape and size
- The liquid level in the tank
- The type of discharge orifice and the drain pipe characteristic, if any.

Let us examine the elements of the problem.

Discharge Through an Orifice, a Short Tube or a Nozzle. The coefficient of discharge C_o in the flow formula $Q = k\ C_o\ d_o{}^2\sqrt{2gh}$, derived from the Torricelli theory, results from the experimental coefficient of velocity C_v and the coefficient of the flow contraction, i.e., the ratio of the cross-section of the stream at the vena-contracta to the area of the orifice. C_o depends on the orifice type and diameter, head, tank diameter and the Reynolds number.[1,2] Yet, for a fluid discharging from a tank through a small orifice (relatively), the coefficient of discharge will be practically constant as long as the head is greater than about 4 times the orifice diameter. With a lower head a free spiral vortex will form, with an air core. The effective area of the discharge orifice will thus decrease, and the discharge time of a given volume will accordingly increase. The discharge coefficient of an orifice with a vortex fully developed may decrease to about 25 percent of its full flow value.[1]

The formation of a vortex and its effects may be greatly reduced by use of a perforated plate at the orifice which, by the way, will also modify the discharge coefficient value. Usually a vortex will not form in a pressurized tank.

Let us also note that discharge coefficients of flows with Reynolds Numbers greater than about 30,000 (in a 1-inch pipe) and about 75,000 (in a 6-inch pipe) will be practically independent of fluid viscosity.[2]

For liquid petroleum products, the value of the discharge coefficient C_o can be read from graphs in books and catalogues[2] where C_o is given as a function of the Reynolds Number and diameter (orifice to pipe) ratio.

All work in this article is based on a discharge coefficient of 0.6, an experimental value for a thin plate, circular, sharp-edge orifice and for a low ratio of d/D. However, any other coefficient can be easily substituted.

Discharge Through a Pipe. In most cases, instead of an orifice with a plug, there will be provided a drain pipe or at least a connection with a globe valve. Either arrangement will create some pressure drop of the flowing fluid and consequently the time to drain a tank will increase. How much? To answer this question we use the well known hydraulic method of equivalence by replacing the pipe-valve systems with an equivalent orifice. Let us select a sharp-edged orifice, with a discharge coefficient of 0.6.

The total pressure drop is built up by

1. The pipe entrance head loss
$$h_L = k_1 c_L \frac{v^2}{2g}$$
2. The pipe exit head loss
$$h_E = k_2 c_E \frac{v^2}{2g}$$
3. The pipe resistance
$$h_p = k_3\, f \frac{L}{d_p} \cdot \frac{v^2}{2g}$$

and since, from the continuity equation $Q = \text{area} \times \text{velocity}$, the total pressure drop expressed in feet of fluid will be

$$h = k_3\, f\, L \frac{Q^2}{d_p{}^5} + k \frac{Q^2}{d_p{}^4}(c_L + c_E)$$

Now, as an orifice pressure drop, from $Q = k_4 c_o d_o{}^2\sqrt{2gh}$ is $h = \dfrac{Q^2}{k_4{}^2\ c_o{}^2\ d_o{}^2}$, equating and reducing

$$\frac{d_p{}^5}{c_o{}^2\,[12\,f\,L + (c_L + c_E)\,d_p]} = d_o{}^4 \qquad (1)$$

This expression gives d_o, the equiva-

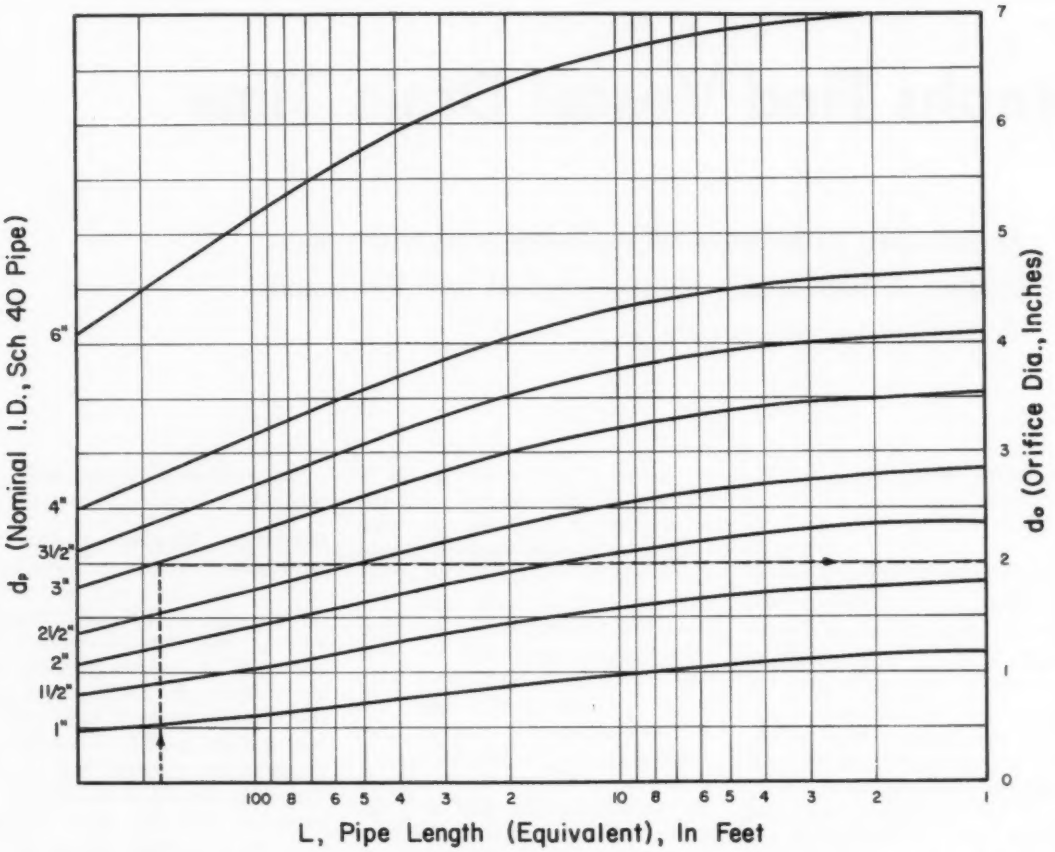


FIGURE 1—If you are draining through a pipe, this nomograph converts the pipe to an equivalent orifice size.

lent orifice diameter, i.e., the diameter of an orifice which will produce the same pressure drop as a pipe of diameter d_p equivalent length L, average friction coefficient f, the coefficients $(c_L + c_E)$ being equal to 1.5.

This equation does not apply to pipes with equivalent length L less than about 5 pipe diameters. Such short pipes are referred to as short tubes and special discharge coefficients are to be used.[3]

The equation (1) is solved in a graphical form on Figure 1.

Tank Shape. The time required to drain a tank is a function of the tank shape. In texts,[1,5] a general method showing how to integrate the variable head for uniformly varying tank cross-sectional area is given. With special shapes, such as horizontal, cylindrical tanks, the computations are more involved.

Vertical, Cylindrical Tank. One of the simplest and most common shapes is a vertical cylinder tank. Suppose that such a tank of D ft., inside diameter is equipped with a small, sharp-edged orifice of diameter d inches. The orifice may be located in the bottom of the tank or on the cylindrical wall, near the bottom edge. Assume the initial water level is h ft. The time, in minutes, to drain the tank is given by

$$\frac{D^2}{d^2}\sqrt{h} = \text{time} \qquad (2)$$

This formula contains the orifice discharge coefficient of 0.6. Figure 2 gives its graphical solution. If time of only partial drain is desired, from level h_1 to level h_2, the time required will be

$$= \sqrt{h_1}\left(\frac{D}{d}\right)^2 - \sqrt{h_2}\left(\frac{D}{d}\right)^2.$$

As mentioned in the preceding section, the time of complete tank drainage, as computed by the above formulae is only an approximation. However, a drainage down to a depth of 4 d_o only, may be calculated exactly. The last few inches of water column will require more time to drain because of the vortex air core which will restrict the free flow area. Suppose that the opening is not a thin-plate, sharp-edge, round hole, but rather a well rounded one whose discharge coefficient is 0.98. To get the time of level change from h_1 to h_2, first determine from Figure 2 the time required to drain using a sharp-edged orifice. The resulting time multiplied by the ratio $\frac{.60}{.98}$ will give the time required using a rounded orifice.

In practice, there will always be some uncertainty concerning the

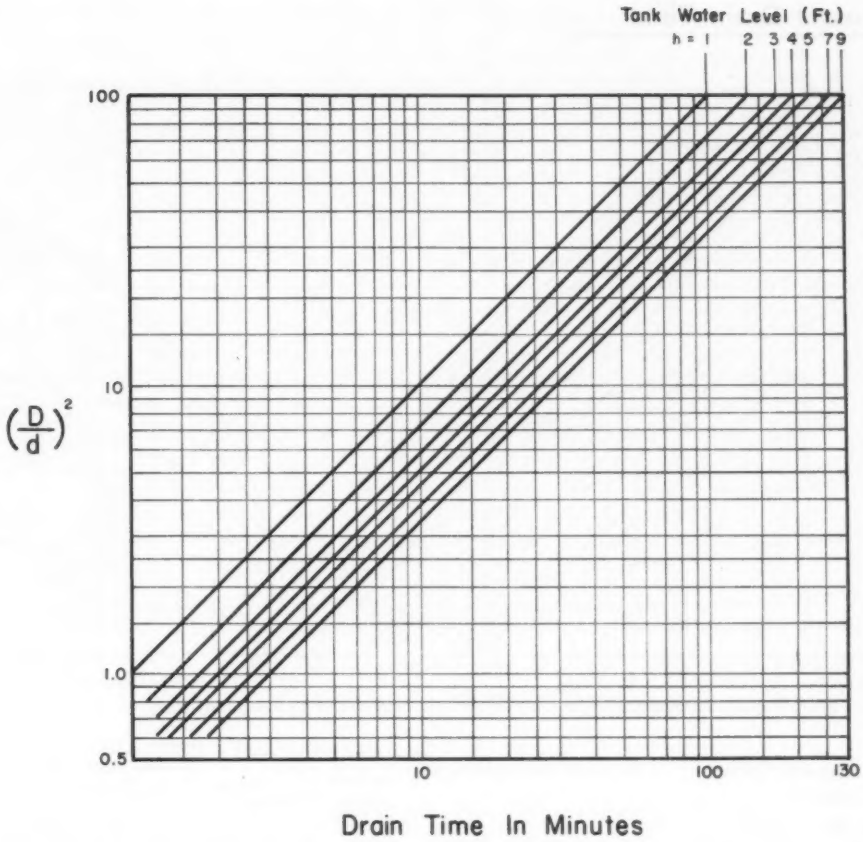


FIGURE 2—The drain time of a vertical, cylindrical tank is simply a function of the tank ID, the orifice diameter and the water level.

determination of the discharge coefficient. For this reason, a sharp-edged orifice coefficient of 0.6 was used in the preparation of the graph; it produces the most constricted flow and consequently will call for the longest time to empty a tank. In other words, the values thus obtained will be conservative.

Horizontal, Cylindrical Tank. The second most common tank will be a horizontal, cylindrical tank. For the time being, let us consider flat ends. The time, in minutes, to empty through a sharp-edged orifice is given by

$$0.845\frac{1}{d_o^2}[\ (D)^{3/2} - (D\text{-}h)^{3/2}\ ] = \text{time}$$

This formula contains a discharge coefficient of 0.6. Figure 3 gives a graphical presentation of this relation.

All remarks formulated before in connection with the outflow vortex formation, the correction to be applied for a different orifice and/or short tube, etc., also apply here.

The flat-end tube is rather exceptional. Usually a horizontal, cylindrical tank will be provided with shaped, dished ends. The most popular are the standard flanged and dished, the flanged and dished as per API and ASME Codes and the elliptical dished ends.

A dished head increases the tank volume and introduces a new variable in the equation of the outflow as a function of time. Whatever the type of dished head, an exact analysis of its capacity as a function of water level would introduce an important and unwanted complication into the time estimate procedure. Above all, it is not worthwhile. A "standard tank" (if there is any standardization of it) has the capacity of its dished heads equal to about 5 to 15 percent of its total capacity and an approximated simplified form for a dished head can be found whose instanteous volume would not differ to any important degree.

The handiest approximated form is a length of a cylindrical tank. For instance, a six foot diameter, elliptical dish may be approximated as a one foot length of a six foot diameter cylindrical tank because

$$\frac{\text{volume of dish}}{\text{section area of cylindrical tank}} = \text{length} = \frac{28.275}{\pi 6^2/4} = 1 \text{ ft.}$$

This equivalent length of the cylindrical tank has the same total volume as the dished head. When a tank is about 20 percent or about 80 percent full, there is quite a discrepancy between a dished head capacity and the capacity of the substituted length of cylindrical tank. Fortunately, for all practical purposes, this discrepancy may be disregarded because it will be small (less than 2 percent) when compared to the volume of liquid contained

Graphs Find Vessel Drain Time . . .

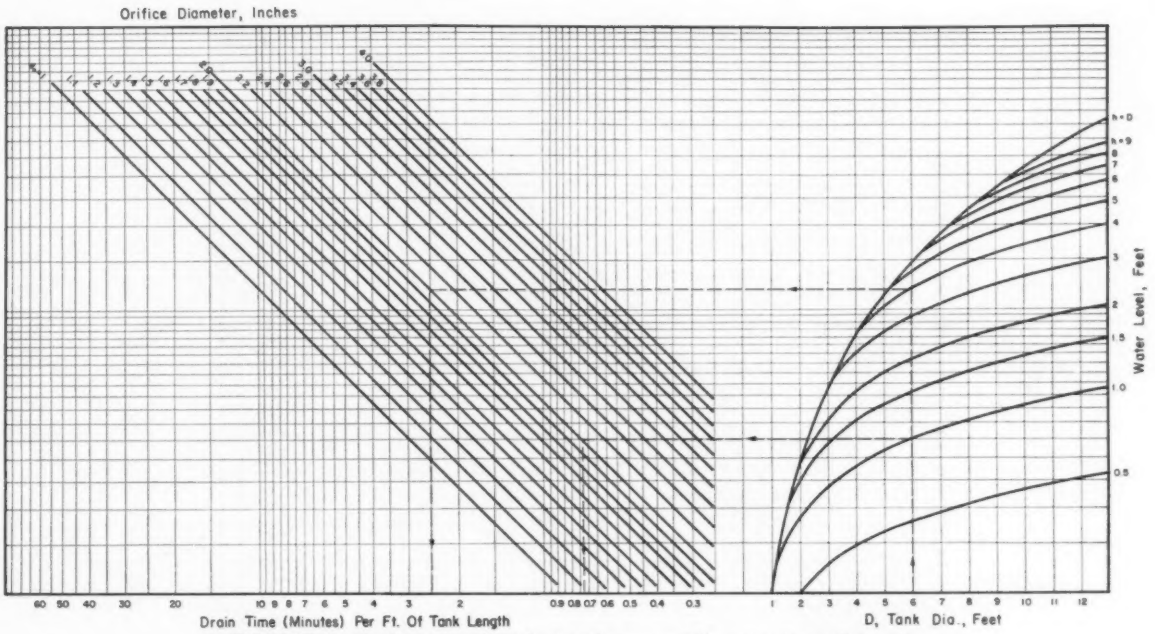


FIGURE 3—Horizontal, cylindrical tanks are considered to have flat ends.

in the tank and consequently, in the present case, insignificant.

Using the graphs, the drain time of any cylindrical tank may be estimated. The drain through an orifice, a nozzle or a pipe may be computed. If any other flow, friction or contraction coefficient is desired, rather than those used in the graphs, the related formulae are available for more specific applications.

Example: Given: tank type—horizontal, cylindrical, diameter—6 feet, length (cylindrical)—14 feet, head type—(API-ASME) Code, Initial water level—4 ft., Required final water level—1 ft., Drain through a pipe, equivalent length—180 ft. pipe size, sch 40, 3 inch, friction coefficient 0.02.

Problem: compute the time to drain, in minutes.

Solution: From a catalog, we get the dished head capacity:

1 head (API-ASME) Code, 72 inch dia.	= 128 gal.
2 heads 128 x 2 ÷ 7.48	= 34.2 cu ft
flange length	= 2½ inch

To substitute a cylindrical section for dished heads, we calculate the section length. It is,

$$\frac{34.2}{\frac{\pi 6^2}{4}} = \frac{34.2}{28.27} = 1.21 \text{ ft.}$$

The tank (flat ends) is now

$$14 + 1.21 + \frac{2\frac{1}{2} \times 2}{12} = 15.63 \text{ ft. long}$$

A 2-inch equivalent orifice diameter is found from Figure 1 by entering the chart at the equivalent pipe length of 180 feet.

From Figure 3 find, as indicated by the dotted line, 2.5 min/ft of tank, to drain completely. Also .73 minutes to drain from a level of 1 foot down to zero. Consequently 2.5 — .73 = 1.77 min. are required to drain from 4 to 1 foot, per foot of tank length.

Total time is 1.77 x 15.63 = 27.7 minutes.

NOMENCLATURE

d_o	orifice diameter	inches
d_p	pipe inside diameter	inches
D	tank inside diameter	feet
L	pipe equivalent length	feet
l	tank length (cylindrical part)	feet
h	liquid level in tank	feet
v	fluid velocity	feet/sec
c_o	orifice coefficient of discharge	..
c_L	pipe entrance loss coefficient	..
c_E	pipe exit loss coefficient	..
k	a constant	
f	friction coefficient	..
t	time	minutes
Q	Volumetric flow rate	cu. ft./unit time

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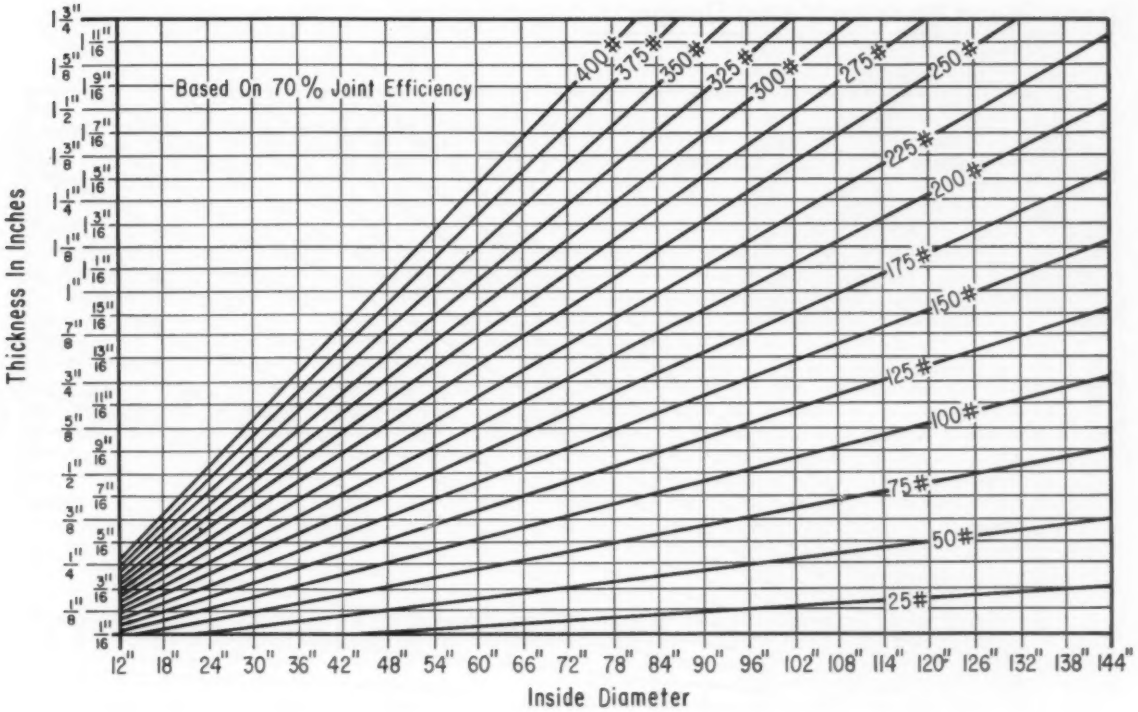
[6] Lukens Spun Heads, Lukens Steel Co., 1955.

About the Author

W. A. Rostafinski is a senior development engineer for Pesco Products Division, Borg-Warner Corp., Bedford, Ohio, where he works in heat balance, heat transfer and thermodynamic design. He had previously been with Arthur G. McKee & Co.'s Industrial Engineering Department, Cleveland. Rostafinski started his technical education in Warsaw, Poland, and graduated from Belgium's Louvain University. Before coming to the United States in 1953 he was with a Brussels consulting firm working in thermodynamic and heat engineering activities. He is currently studying for a Ph.D. degree at Case Institute of Technology.



For Stress Values Other Than 13,750 PSI

Allowable Stress	Constant
11,250 psi multiply chart thickness by	1.222
12,500 psi multiply chart thickness by	1.1
15,000 psi multiply chart thickness by	.9167
16,250 psi multiply chart thickness by	.846
17,500 psi multiply chart thickness by	.7857
18,750 psi multiply chart thickness by	.733

$$t = \frac{PR}{SE - 0.6P}$$

t = thickness
p = internal pressure
S = allowable stress 13,750 psi
E = Efficiency of joint
R = Inside radius

FIGURE 1—Cylindrical Shell Thickness Chart

Charts Speed Pressure Vessel Design

Revised ASME Pressure Vessel Code sets up new welded joint efficiencies. Charts pick shell thickness quickly

Robert Chuse
Leonia, N. J.

THE 1959 edition of the ASME Unfired Pressure Vessel Code, Section 8, contains major changes in the welded joint efficiencies. The code now allows 100 percent efficiency for double welded butt longitudinal joints that are fully radiographed, 85 percent efficiency for joints that are spot radiographed, and 70 percent for joints that are not spot radiographed.

For carbon steel vessels that are to contain air, steam, or water, a corrosion allowance as required in Par. UCS 25, must be added to vessels that are radiographed or spot radiographed. This requirement does not apply to vessels that are not spot radiographed.

The thickness required is obtained by simply following the diameter line up to the pressure line, then horizontally to the left side, and reading the thickness value.

ACKNOWLEDGMENT

Reprinted from the copyrighted book, "The Unfired Pressure Vessel Code Simplified," by Robert Chuse, Leonia, N. J.

(Figures 2 and 3 on next page)

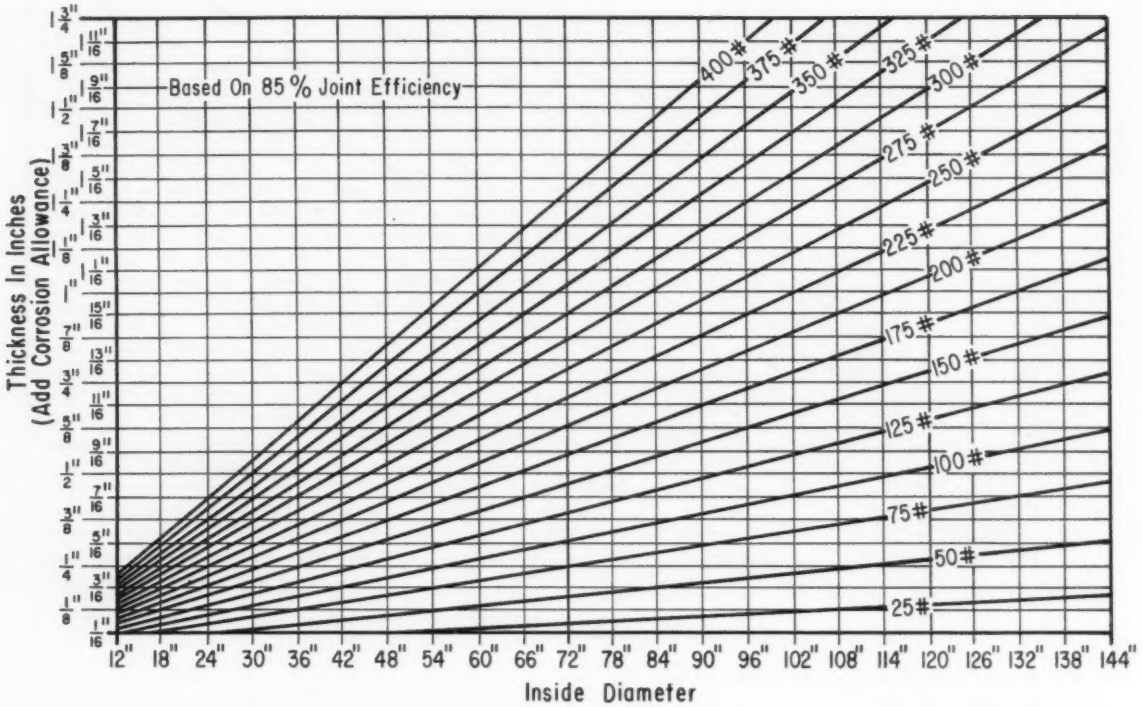


FIGURE 2—Cylindrical Shell Thickness Chart

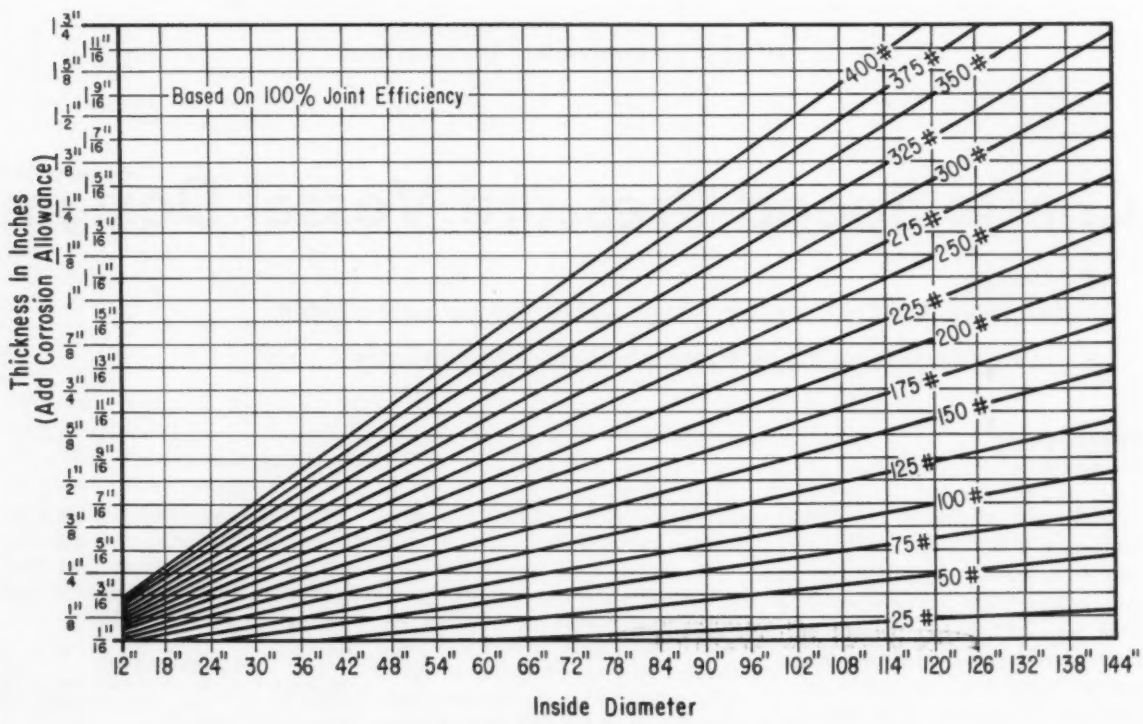


FIGURE 3—Cylindrical Shell Thickness Chart

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Port Chicago (San Francisco), California
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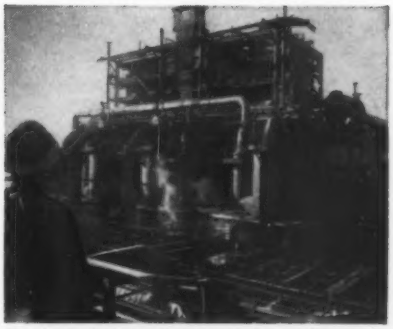

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(Kohl, A. L. and Riesenfeld, F. C., *Gas Purification,* McGraw-Hill Book Co., 556 pages, $15. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas.)

Industrial Complex Analysis

"Industrial Complex Analysis and Regional Development" leads the reader, by means of a case study, to a technique for comparing interrelated industrial activities. This technique achieves the major objectives of an inter-industry approach while sacrificing none of the detailed analysis of the individual industry comparative cost approach. It permits consideration and comparison of the quantitative and qualitative aspects of regional advantage.

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(Isard, Walter, Schooler, E. W. and Vietorisz, Thomas, *Industrial Complex Analysis and Regional Development,* The Technology Press and John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 294 pages, $8.75.)

Filing Bibliography

"Bibliography on Filing, Classification, and Indexing Systems for Engineering Offices and Libraries" has been published. This is a selected list of references prepared for engineers and librarians concerned with organizing their own files or those in engineering offices or libraries where they work. The references are to books, pamphlets and magazine articles on filing, classification and indexing. Included also are lists of subject headings, hand-sorted punched-card systems suitable for organizing small collections of engineering books, notes, correspondence, abstracts, reprints, drawings, maps, manufacturers' catalogs, etc. Some listed items are broadly applicable; others are related to specific subject fields. There is a subject index and an introduction in which selection and use of the systems are discussed.

(ESL, *Bibliography on Filing, Classification, and Indexing Systems for Engineering Offices and Libraries,* Engineering Societies Library, 29 West 39th St., New York 18, N.Y., 33 pages, $2.)

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"Petroleum Products Handbook" is a convenient reference to the methods, data, and working information needed for efficiently and economically using petroleum products. It supplies coverage also in such areas as additives, petrochemicals, petroleum waxes and petroleum asphalts. Written by 32 specialists, it covers diesel fuel oils, lubricating oils and greases, aircraft gas turbine fuels, distillate heating oils, liquefied petroleum gas, and the other important petroleum products.

For each product the handbook describes properties, characteristics, and performance—to aid in selecting the right product for any specific requirement. It also clearly explains and illustrates methods of handling and using the product, including testing for required properties. Extensive tables of data are provided for each product. In addition, a reference data directory enables the reader to locate all published sources of data on tests and specifications; storage, shipping, and handling regulations; and other information.

(Guthrie, Virgil B. (Editor), *Petroleum Products Handbook,* McGraw-Hill Book Co., 864 pages, $18.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

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(API, *Petroleum Facts and Figures (Centennial Edition),* American Petroleum Institute, 1271 Avenue of the Americas, New York 20, N. Y., 476 pages, $4.50. Free to API members.)

Heat Exchanger Response

"Transient Response of Double-Fluid Heat Exchangers" (PB 151905) discusses an investigation of the dynamic response of two-fluid heat exchangers to a time-dependent temperature at the inlet of the primary fluid. Three flow rates were studied in each of two test heat exchangers under parallel and counter flow conditions. Flow velocities were 3 feet per second, 6 feet per second, and 9.3 feet per second in both the inside tube and the annulus of the test heat exchanger. Reynolds numbers corresponding to these flow rates were 25,000, 52,000 and 81,400 in the inside tube and 2,800, 5,300, and 8,060 in the annulus. Both steady state conditions and transient records are reported. Output of the counterflow heat exchanger is correlated with earlier published data.

(OTS, *Transient Response of Double-Fluid Heat Exchangers, (PB 151905)* Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., 92 pages, $2.25)

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(Royal Dutch Shell, *The Petroleum Handbook,* Shell International Petroleum Co., Ltd., St. Helen's Court, Great St. Helen's, London, England, 678 pages, $3.)

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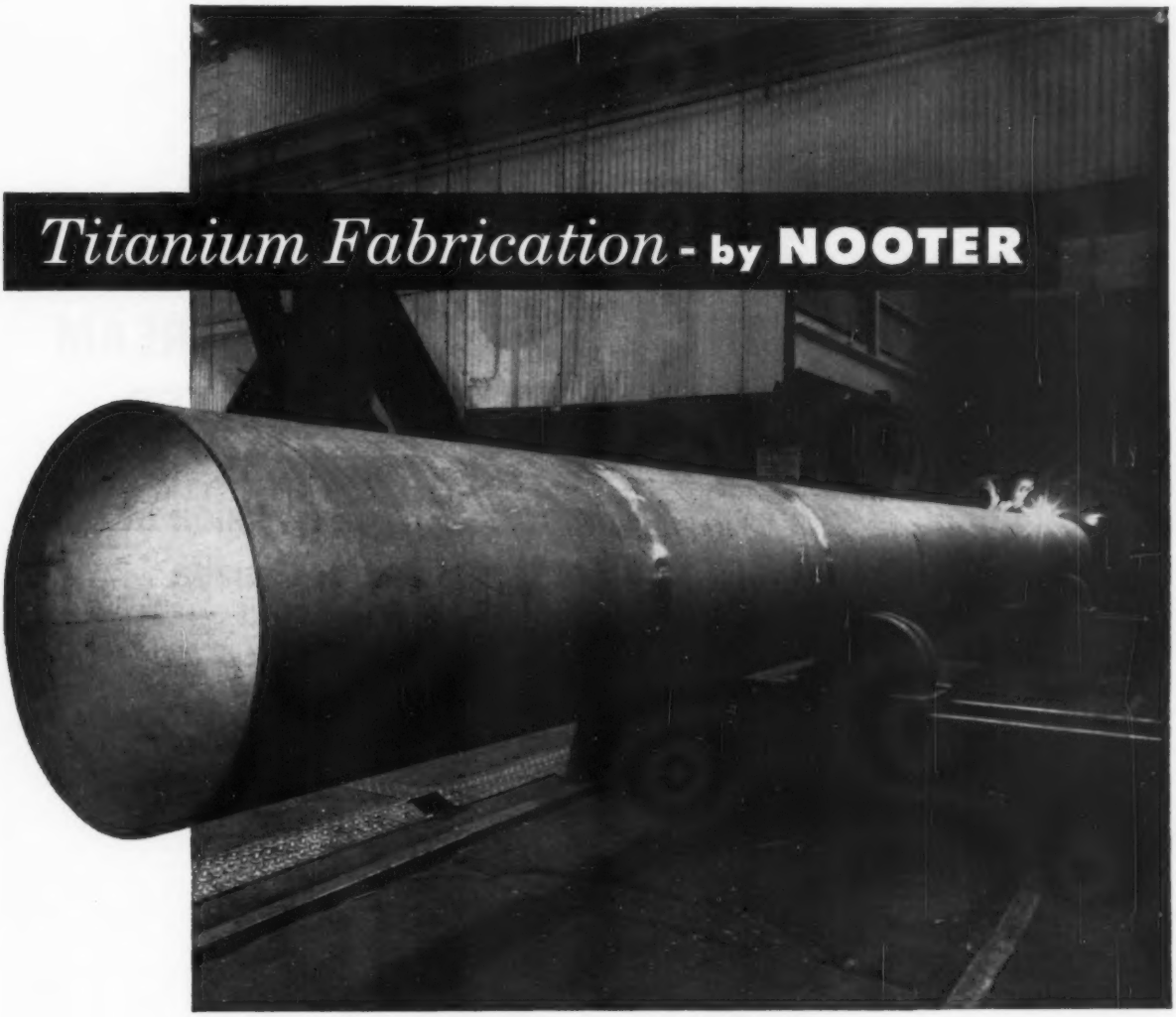

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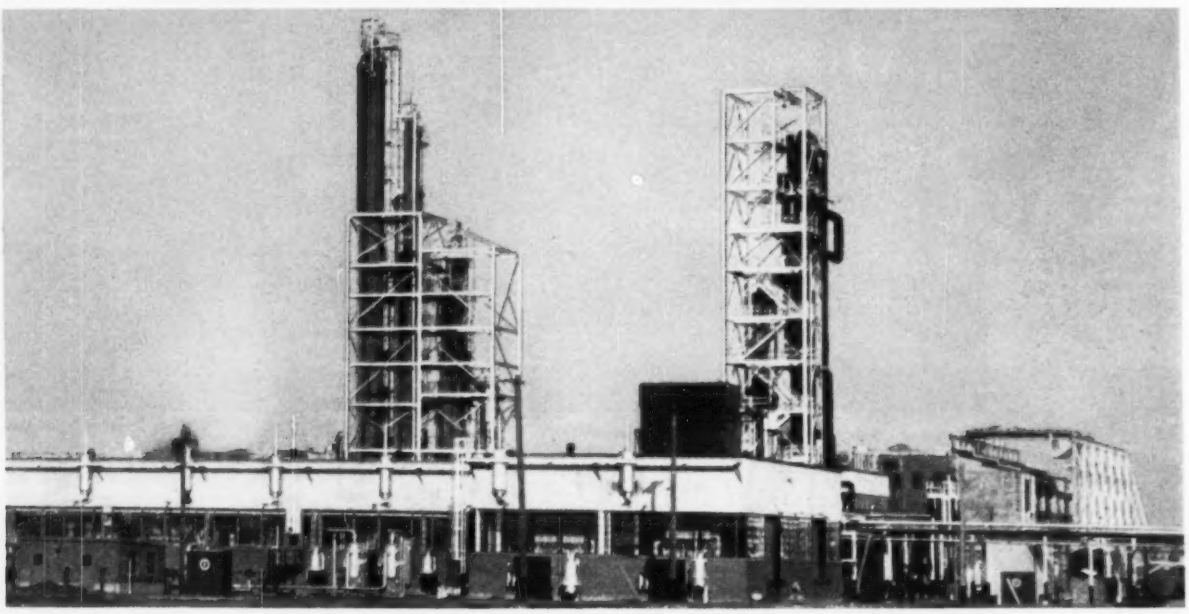

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How to Run a Testing Program

A good testing program is a valuable management tool in employe selection, placement and evaluation. You should, however, consider these points before launching a program

John D. Quinton
Tennessee Gas Transmission Co.
Houston

THE PSYCHOLOGICAL tests given in industry today are used in arriving at decisions which may have great influence on the ultimate welfare of the employes tested, and of the company. Test users, therefore, should apply high standards of professional judgment in setting up a testing program.

Before launching the testing program upon a sometimes rough and stormy industrial climate, there are a few factores that should be considered. If a company is unwilling to go the correct route in establishing a "complete" and sound program it is perhaps better to stay out of testing altogether.

What is meant by a "program?" A program, as far as testing is concerned, implies orderliness and planning. It is a systematized procedure of carrying through the testing sequence, instead of a one-shot or sporadic farce. The hit-or-miss technique has been one of the chief reasons for the failure of many industrial testing ventures.

Administrator should practice

Another historical weakness is the use of a short-range or one-time testing venture that produces only a fraction of the positive results that a well planned, varied, long-range program could produce.

Before we look at the general procedures for developing a testing program, however, we should consider certain factors about tests and testing. If you are toying with the idea of testing employees, you may want to put off your program after considering these points. Because, if your thinking is not compatible

with these, there is no reason for launching into the testing program itself.

HOW TO TEST

1. Standardized tests can help in the selection and placement of employes only when used intelligently by personnel people. The test producers have produced tests that can be of the greatest possible service and have also supplied manuals and associated aids that are unambiguous, comprehensible and complete. Such directions and information must be followed precisely and intelligently or else the results will be misleading and useless.

2. Test results should be used. If all the test results that have never been used and are lying in locked files were stacked in one stack the Empire State Building could rest in its shadow. Many millions of manhours and dollars have been wasted on testing programs where the tests were given, scored and "locked in a secret file" to serve no purpose other than take up valuable storage space.

3. Use the results not only for selection and placement but as a stimulant for personnel people to change their methods, redefine their purposes and modernize their procedures and policies.

4. No final and important decision should be made on the test results alone. Psychological tests and methods should be used only as supplements to other employment procedures.

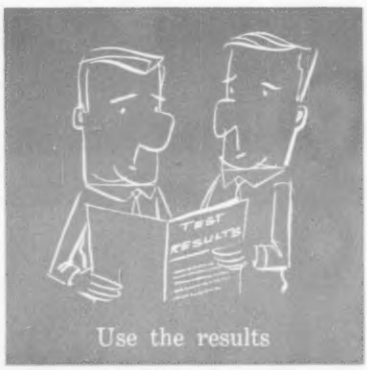
5. Do not reproduce the whole or any part of a test. It is a violation of the author's or publisher's copyright. In addition, many tests have been standardized using an exact and predetermined format. Any changing of the format would invalidate the test results.

6. It is better to give a battery of several tests than to rely upon a single test.

If the corporate thinking of people involved in planning a testing program can pass this test, then (and only then) should they consider these procedures for developing a testing program. Whether you are considering a limited or a long-range, comprehensive testing program, the chronological steps to follow in a complete program are as follows:

Ascertain The Purpose. What are you going to do with the results? Do not be too general, but be as specific as possible. "To improve the selection and placement of personnel" is not specific enough and can be classed as a "Mother Hubbard." "To improve the selection of technicians and draftsmen and thereby reduce turnover," is better.

The purpose should define both the type and scope of program you will develop. One word of caution though: do not try to undertake too large a program at first. In fact, it would be better to be less ambitious by starting small where success is more assured.



Use the results

Keep records confidential

Actually, there are two important factors to keep in mind while determining the purpose, or the testing program is doomed before it gets started. These are:

1. Ascertaining the purpose must be a combined effort. The program will not go well if one person or section determines the purpose and passes it on to everyone else. The success of the program depends upon its acceptance by all who will use it and upon their having participated in its formulation from beginning to end.

2. It must be a practical purpose. It would pay dividends if you would make a list of questions and problems that could be solved by testing. Again, testing should not be done just for testing's sake.

An imaginative and creative manager will use the test results in a variety of practical ways which will more than offset the modest cost for test material.

Selecting the Tests. Tests for selection, placement and advancement of personnel are classified in several different ways. They can be group or individual; aptitude or achievement; instrumental or paper and pencil; I. Q. or informational, etc. Since it is highly important to select the correct tests for the predetermined purpose and to use only tests that have themselves been tested, it is imperative that the best qualified persons make the selection.

If your company does not have such persons on its staff, a reliable industrial or clinical psychologist can be called upon. These people are thoroughly trained and experienced and can work closely with the company in planning the testing program.

Giving The Tests. This step is extremely important. If the tests are administered by an incompetent person the entire testing program has failed. It might be wise, then, to select tests whose administration is not beyond the capabilities of company personnel. The administrators should practice giving the tests many times until there is no doubt about their efficiency. Many testers find that it helps to take the tests before giving them. This makes it possible for them to understand the problems of those taking the tests.

The tests should be given under as ideal a situation as possible. This would include:

1. A well lighted room that is not too hot or cold.

2. Privacy—avoiding all distractions and interruptions.

3. Comfortable table and chair.

The administrator, too, must meet certain requirements. He must be able to read well and give instructions clearly. He must keep time accurately, using a precision stop watch. A few seconds over or under

the time limit will invalidate some tests.

And last, and immeasurably important, is the following of directions for administration—directions *must be followed exactly*. Any change or modification in giving the tests will invalidate the results and the analyst will not be able to compare them with the norms for that particular test.

The administrator should also be courteous, sympathetic, and understanding. Often he spends more time with an applicant than anyone else. Since first impressions are lasting, the employes that are hired will judge the company by those impressions, and rejected applicants will form their opinions of the company on these first impressions. If the impressions are good the company will retain a customer; if bad, not only will the company lose this customer but he will influence others to buy other companies' products.

Thus, a very important part of the administrator's job is to be sure the people react favorably toward him, the tests, and the company.

Scoring. Don't let the apparently simple procedure of scoring fool you. Studies show that, even when scoring keys are simple and objective, many scoring errors are possible. Errors are due to misreading or misunderstanding the scoring directions, carelessness, errors in adding and subtracting, transposing numbers, misuse of scoring key, and errors in entering scores in appropriate places.

To prevent errors the scorer should study the tests, the manual and the scoring key. He should be taught how to score and not left to his own learning devices. In addition, a random sampling of scored tests should be rechecked to determine the accuracy of the scorer. Absolute accuracy should be the goal of both the scorer and the company. A lasting injustice can be done an applicant when the scorer is careless and inaccurate.

Interpreting The Scores. It is beyond the scope of this article to go into all the ramifications of the statistical analysis of scores, graphical presentation, use of norms and the analysis of errors. However, it is obvious that the value of test scores will depend upon how well they are understood and interpreted.

Generally speaking, most tests are of the type whose test scores can be compared with "norms." These norms are supplied by the individual who standardized the test. If an applicant is up-to-norm on a test he is average. If he is above norm he is better than average.

In other words, the applicant is being compared with hundreds of other people who have taken the test. However, if a tester knows from actual trial that persons above a specific score make satisfactory employes, it is not necessary for him to compare the applicant with the test norms. Furthermore, after a test battery has been used for some time, the company may want to set its own norms or standards.

Regardless of how norms and other standards are used, the person interpreting test scores must know what he is doing. Since norms and standards are usually presented as means, percentages, or standard scores, the interpreter must have at least a rudimentary knowledge of such measurements.

The important part is that the tests are only as good as the interpreter. Therefore, a person trained in analyzing and interpreting scores is a necessity in any testing program.

Using The Results. Proper use of test results is the most important step in the entire testing program. All the effort and time expended on the selection, giving, scoring and interpreting of the tests is wasted if the results are not used or if they are improperly used.

The use of the results, of course, depends upon the purpose of the testing program. Was it to select better technicians? Or better engineers? Or were they used to find personality difficulties among present employes? Or were they to help in the selection and placement of craftsmen from present employes?

Whatever the purpose, the essential point is that the test results should be used; for the failure to use the results in a practical way is to toll the death knell of the testing program.

In addition, well-kept records of the results are indispensable to the success of a testing program. These records can be used for further study, for reporting progress and success to the department manager, the administrative group and other interested parties. Such records and reports should, in all cases, be kept confidential and in a locked file.

In Conclusion. We can see that the undertaking of a testing program is a serious and not uncomplicated procedure. The general procedure as outlined in the article is to ascertain the purpose, select the proper tests, administer them correctly, score them accurately, interpret the scores expertly and then use the results in as practical a way as possible.

The proper development and use of a testing program should give direction and efficiency to employe selection, placement and evaluation. The program can add a great deal to a manager's box of tools for objective and scientific fact finding.

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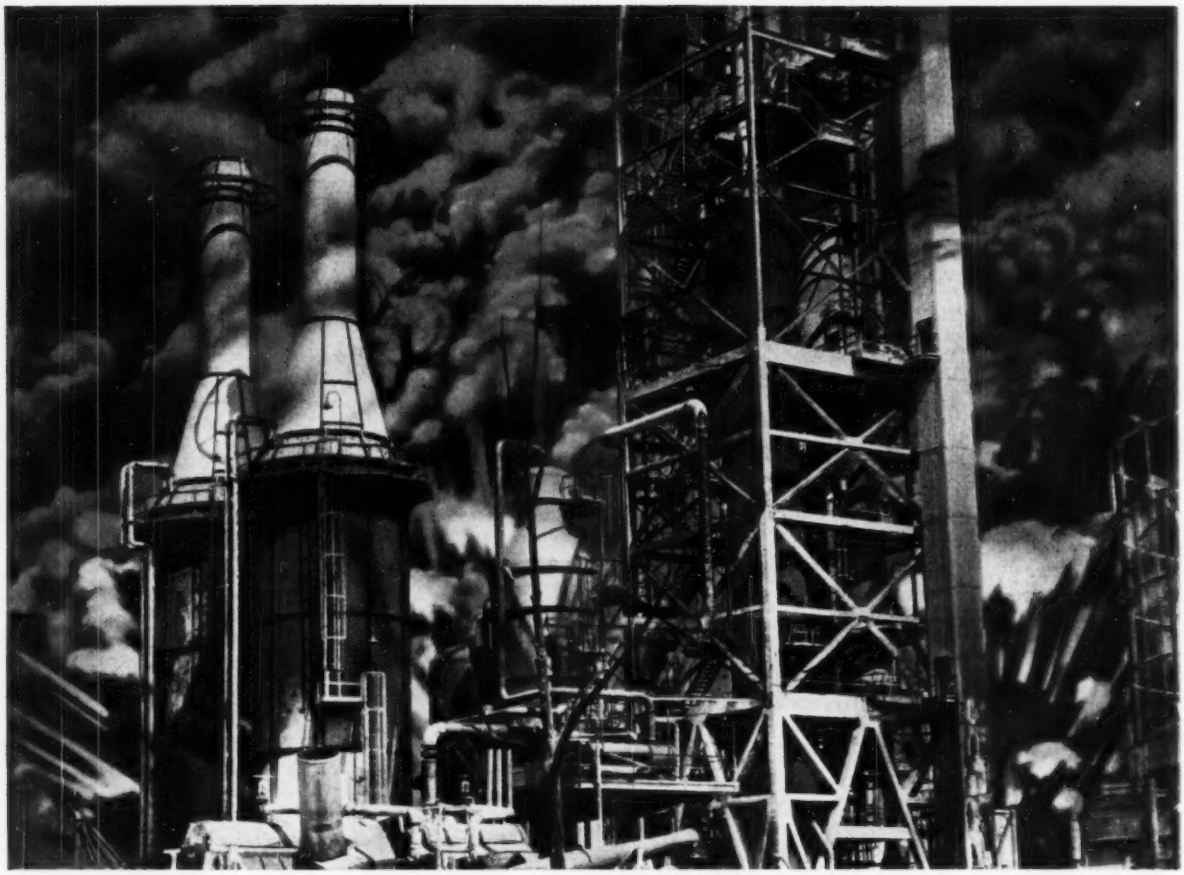
About the Author

John D. Quinton is a training representative for Tennessee Gas Transmission Co., Houston, where he develops and presents training programs. Holder of a B.A. degree from Lincoln Memorial University and a M.A. degree from Tulsa University, he also completed two years' work toward a Ph.D. degree at Kansas University. All of Quinton's studies have been in industrial and clinical psychology. He has been a professor at Kansas and Tulsa universities, and has headed the Psychology Department at Arkansas Polytechnic College. Quinton was a consultant for Service Pipe Line Co., Tulsa, for two years, and a training representative for Shell Pipe Line Corp., for four years, before joining Tennessee Gas.



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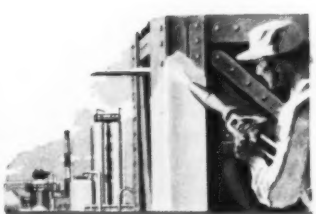

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Fire Safety Economics: Part 1

Design Safety Into Your Plant

Here are some valuable pointers which will help you achieve maximum fire safety in your operations. As additional benefits, you'll get better employe morale, minimum maintenance costs and lower insurance rates

James J. Duggan

Union Carbide Chemicals Co.
South Charleston, W. Va.

THIS MATERIAL was prepared for publication by Mr. Duggan from engineering reports, data and standards in cooperation with staff groups under the direction of:

J. Lee Marsh, Vice-president, Development.

R. W. King, Director of Engineering.

A. P. Dunlap, Fire Protection, Engineering.

D. H. Way, Fire Research Laboratory.

W. W. Baker, Design and Construction of the Union Carbide Chemicals Co. and the various committees of the National Fire Protection Association.

THE PETROLEUM and petrochemical industry has grown by leaps and bounds and is continuing to do so—and with this growth have come increased responsibilities in the area of fire safety due to

- Larger volumes of flammables being stored
- Higher processing temperatures and pressures
- New and more "exotic" products being handled

Careful planning, from the drafting board right up to training and procedures, the manuals for the operating plant, can do much to insure fire safety and save money. The objectives of fire safety and prevention are to minimize opportunities for personnel injury, loss of life, property damage, and production interruption. These objectives are achieved by

- Prevention
- Control
- Extinguishment

Let us consider these in turn with particular emphasis on economical design for fire prevention and fire control, and on the actual economics involved.

FIGURE 1—Numbers and colors are used to identify materials according to flammability, stability and toxicity.

PLANT LAYOUT

Since fires may and do occur, one of the basic fundamentals of all design is segregation. That is, to minimize damage and to permit effective control and extinguishment. A good approach to this is to carefully evaluate the occupancies involved and the lay-out required for production facilities.

For example, such occupancies might include offices, cafeterias, lockers, shops, stores, dispensaries, yard storage and other services in administrative buildings. These should be grouped within a certain area of the plant, with suitable spacing between the individual occupancies. Make provision for proper fire extinguishing mediums in accordance with standard regulations. Garages can be included in this group if treated in the same way.

Fired Heaters. It would be preferable to locate steam power plants on boundary areas. However, economics indicate centralized locations, so spacing between these adjacent occupancies should be considered. This also applies to fired processes such as furnaces located adjacent to processing areas.

Process Units. Processing units can be grouped according to the type of flammable material handled. For example, high pressure gas and liquefied petroleum gas processing units should be grouped together. Bulk storage of finished product should be isolated from other occupancies and also producing units.

Ordinary flammable liquids processing units should likewise be grouped, however, in many cases, unstable or reactive compounds must be used with ordinary flammable liquids and stable materials. Therefore, conditions of temperature and pressure may change the entire picture from a fire protection standpoint. The need for design methods of prevention then becomes quite evident.

PLANT DESIGN

The design of plant structures and buildings should provide for fire resistance in accordance with the severity of the hazard involved. For example, the building should be so constructed that it will resist exposure to fire for a reasonable length of time. Fire resistant construction should be used in the following instances:

1. Hazardous occupancies to minimize the likelihood of fires spreading throughout the building or doing damage to adjacent buildings.
2. Vital occupancies such as storage vaults, transformer rooms, electrical sub-stations, laboratories, etc.
3. High value occupancies where

any serious fire would cause excessive property damage and production loss.

Recommended practice and experience indicate that fire resistive construction should be provided throughout a processing plant. Thus, employees have a better and safer place to work, housekeeping is easier, morale is higher, and employe relations are better. All these factors tend to free the individual for constructive fire prevention thinking along operational lines. Further, the best protection is obtained at the lowest cost because greater security is guaranteed against major fire. In addition, maintenance costs are minimized and lower insurance rates are possible.

Geographical situations have considerable bearing on the architectural features of an industrial plant. Where processes are contained within buildings for operational comfort or for product cleanliness, added fire protection and control measures become necessary. The building design should provide for explosion venting by means of nonrigid roof construction and free window areas to prevent structural damage. Forced air ventilation systems will prevent formation of flammable vapor air mixtures, however, for more hazardous operations where flammable vapors are continuously released, direct vapor removal systems are necessary.

Water sprays or sprinkler systems are very often required to prevent damage or to extinguish fire when it occurs. These systems are well known and are adequately outlined in National Fire Protection Association Standards.

Electrical Apparatus. The National Electric Code should be followed because electrical apparatus and services normally considered safe for ordinary occupancies have been proven unsafe for installations in locations where flammable gases, liquids, and dust are handled. With the growth of the oil, gas and petrochemical processing industry, electrical equipment and the methods of using it have developed to such an extent that plant designers are now able to prevent many fires and explosions previously attributed to electrical sources.

Electrical insulation requirements are presented in the National Electric Code which is accepted widely in industry and by recognized authorities. The electrical equipment that has been tested and found suitable is defined in this code and is listed by the Underwriters' Laboratories, Inc., The Factory Mutual Laboratories, and the U.S. Bureau of Mines. The experience of these groups, coupled with that of industry, now forms a firm basis for safe electrical design in any industrial plant.

Many fires of electrical origin result from overloading, with the resultant overheating. This can be eliminated by protective devices which, when placed on the supply circuits, prevent dangerous overloading. During abnormal periods, electrical apparatus may be forced beyond its rated limits, even to the point of failure unless special emphasis is given to this danger in the installation design.

Instrumentation. Perhaps the most important phase of process control is instrumentation. Processes may be controlled manually when the conditions are known to the operator through indicating or recording instruments. The degree of control so obtained is then dependent upon the response of the operator. If abnormal or complex conditions exist, they may lead to situations for which instrumented controls are necessary for safe operation.

Recently a survey was made of an industrial area in Russia by one of our correspondents. In one Soviet plant ball bearings are manufactured in large volumes without a single human in the building to operate or control the mechanical devices. It is so highly instrumented that the only time men enter the area is for maintenance.

You will agree that if it is possible to realize complete instrumentation of a complicated process like making ball bearings, even to the extent of packaging the product and preparing it for shipment without the aid of the human effort, that we certainly ought to be able to do something about controlling fires and explosions. So, the requirements for design in fire and accident prevention are of paramount importance.

Classifying Materials. Another development that is prominent at the moment is the work being done by the Technical Committees of the National Fire Protection Association. One in particular is a committee on the "Fire Hazards of Materials." An effort is being made to classify all materials by the hazards involved in safe handling. Recent years have seen an increasing number of methods of classifying flammable materials. The National Fire Protection Association alone has six such systems.

Chaos has resulted as the chemical industry tried to follow one set of regulations for transporting flammable liquid, and other regulations for its use. Many experts feel that despite all the regulations, the problems in handling a material safely often aren't clearly indicated. Now, however, this committee has moved industry a step closer to a uniform system of classification by identifying the materials according to safety handling problems. This eliminates the necessity of remembering complicated chemical formulas or chemical names.

This method of classification involves the three handling problems that are based on the chemical and physical properties of materials. The first of these is the flammability of the material, the second is the stability, or we should say, the reactive characteristics of the material, the third is the toxicity.

Flammability. Ignition potential is indicated by the color red, and numerals are used to indicate the degree of flammability. For example, the ignition potential was classified by the flash point and the number 1 classification were those materials which have a flash point about 140° F. The number 2 classification was between 100° and 140° F., the number 3 classification between 73° and 100° F., and the number 4 was all materials with a flash point below 73° F. The latter materials are ignitable under almost all conditions of ambient temperatures except perhaps, in northern winters.

Stability. This definition has been tentatively set out as

1. Normally stable materials.
2. Materials which are reactive with water.
3. Materials which are self-reactive with contaminants and are

pressure and temperature sensitive.

4. Materials that are self-reactive, sensitive to temperature and pressure and shock sensitive.

Toxicity. This problem embraces the effect of exposure to materials and are classified as those:

1. Which result in no residual injury if a person is exposed to it,
2. Where minor residual injury may result if no treatment is applied
3. Where a major residual injury may result if no treatment is applied
4. Which could cause major residual injury in spite of treatment.

These three classifications are also identified by colors, red being the color for fire, yellow for stability and blue for toxicity. Figure 1 shows this classification system in use at the Seadrift, Texas plant of Union Carbide Chemicals Co.

The committee realizes that a new classification in itself will not solve the problem. Widespread cooperation is needed from industry, but by taking a fresh approach to classifying the safe handling limitations, the committee hopes to develop a more constructive and realistic system.

Inert Gas Protection. Another committee of the National Fire Protection Association has concerned itself with the prevention of fires and explosions by inerting, that is, by removing or reducing the oxygen content of the air in closed areas so that fires and explosions cannot occur.

A standard has been issued on this approach to fire safety. It is a step in the right direction because there have been many tank fires which would not have occurred had the oxygen content in the vapor phase of the vessel been below 10 percent. So, inert gases such as nitrogen or carbon dioxide, and in some cases fuel gas, are recommended to reduce the oxygen content to a point where ignition cannot occur.

This is just one of the many, many standards that have come out of the technical committees of the National Fire Protection Association and have been adopted by the National Board of Fire Underwriters, as well as a large majority, if not all, of the insurance engineering departments.

In Part 2, next month, Mr. Duggan will discuss such highly interesting and informative topics as:

1. Five improved methods for storing alcohol or other flammable or toxic liquids.

2. Fire safety ratings and comparison of 10 different types of storage tanks.

3. The annual gross savings which are possible from improved fire-safe tank design.

4. Fire extinguishing techniques and materials.

About the Author

James J. Duggan has been with Union Carbide Chemicals Co. for 36 years, the first 11 being in the fields of construction, maintenance and operation.

For 25 years he worked in fire protection, fire research, and fire protection engineering. Duggan has directed an extensive fire research laboratory with facilities for determining characteristics, physical properties, and fire hazards of all types of combustibles, and large-scale testing facilities of fire extinguishing mediums and equipment on various types of combustibles. He also originated, supervised and directed preventive maintenance programs covering the periodic test and inspection of machinery and equipment as a means of preventing fires and explosions. The past five years Duggan has directed company-wide safety and fire protection.

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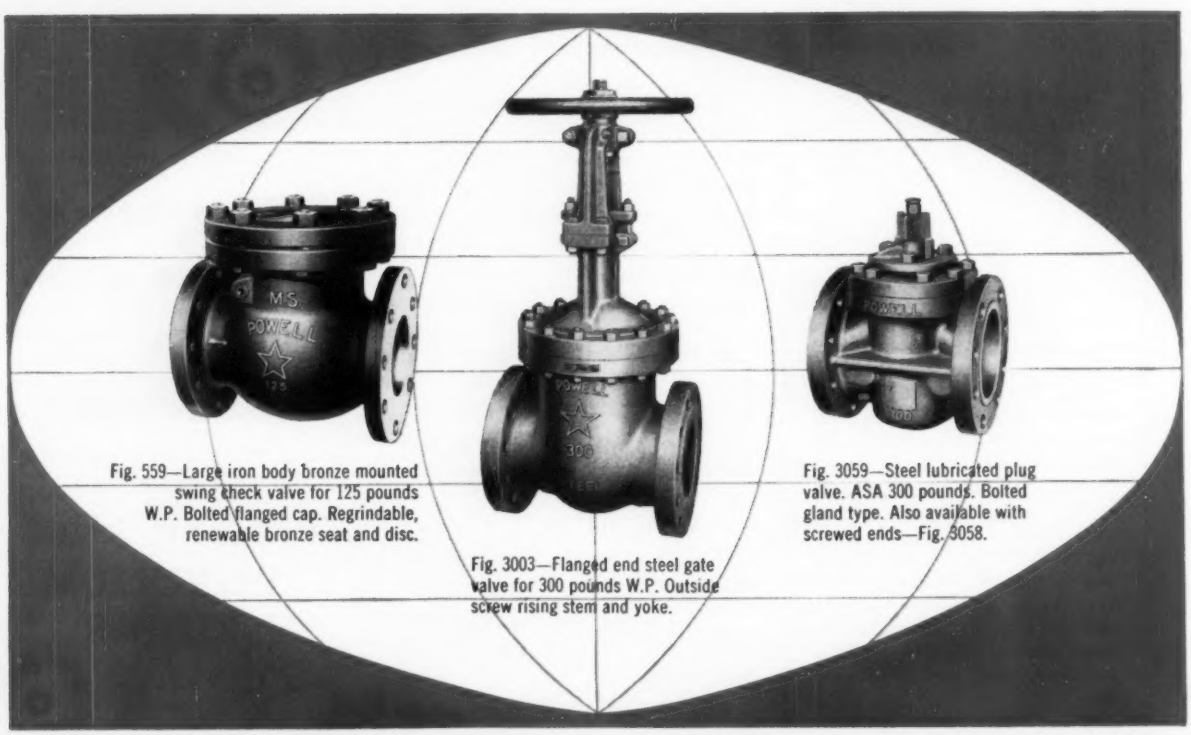

Fig. 559—Large iron body bronze mounted swing check valve for 125 pounds W.P. Bolted flanged cap. Regrindable, renewable bronze seat and disc.

Fig. 3003—Flanged end steel gate valve for 300 pounds W.P. Outside screw rising stem and yoke.

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Employe Publications—'Chit-Chat' Or Management Spokesman?

Today, many employe publications are completely filled with news of bowling teams, picnics and fuzzy pictures of fishermen and babies. Very seldom, however, is there any effort to explain and interpret the issues vital to the company, the industry, and the nation

EMPLOYE PUBLICATIONS have become one of the most important elements in industry's expanding communications program. Most of this growth has been since World War II. Today an estimated 8,000 to 10,000 publications in America boast a combined circulation of more than 150 million, and more are being added every year. Of this total, approximately 330 are published by the oil industry.

Are these newspapers and magazines doing their job? Is management, which is spending $100 million this year to roll them off the presses, making full use of their far-reaching potentialities?

Part of the answer was revealed in the attitudes of some managements during the recession of 1958. When the pinch came, a few corporations abruptly dropped their employe publications. They regarded their company magazines as expendable—and perhaps in some cases they were. Others retained their publications but sliced budgets to the bone—often slicing the effectiveness of their communications effort proportionately.

Many companies, however, simply took a good, hard look at their publications, asking themselves these questions: Can our costs be trimmed without impairing the effectiveness

of our magazine? Can we improve the message it conveys by eliminating waste fat and building muscle? Can we do anything, in these serious times, to see that our publication makes a better contribution to employe understanding of this company and what it stands for?

Through such self-evaluation, numerous corporations came up with face-lifted publications which today are healthier and more forceful than ever before. They also demonstrated an awakening to one of the greatest challenges facing management today: the failure of American business to explain itself and what it believes in to its employes and to society in general.

Some Remain Silent. Despite the efforts of some companies to face up to this challenge and do something about it, the problem is still widely spread in American industry. It is not unrecognized, however. Everywhere, management, supervisory, and editors' groups are being told: We must communicate! We must counteract the steadily-rising power of unionism! We must tell employes our side of the story! But many corporations—through failure to understand how crucial the situation is, or through fear—still have not put these recommendations to work.

What is the explanation for their silence on important issues?

For one thing, some managements are still so unenlightened that they believe company economics are simply none of the employe's business. Other managements (thinking themselves more charitable) feel that business economics are somehow beyond the typical employe's comprehension. Still others are just plain afraid to speak their piece.

Much "Chit-Chat." Their companies' publications reflect these views. Examine their pages. You find reams of news about bowling teams, weddings, picnics, new car owners, and farewell luncheons for mothers-to-be. You wade through out-of-focus pictures of strings of fish, "personals" columns containing little but gossip, and extravagant tributes to the company president on his 25th service anniversary.

You find, in short, a hodgepodge of type slapped together in the hope of promoting "morale" or "good will." Management smiles to itself that "our little magazine" is reaching every employe. "Names make news," they chuckle, and after all, doesn't everyone like to see his name in print. And employes do read it, don't they?

This defense of the sweetness-and-light approach overlooks the fact that communications is today as involved in the money-making end of business as sales or production. The pay-out comes in the form of solid management-employe relations and better production through better understanding by employes of their jobs and their company.

Blame Management. Another view of the "silent treatment" is given by David Summers, president of the Pittsburgh public relations firm bearing his name. He writes: "Management attitude toward employe publications is a paradox. What well-run company would make an investment without expecting a fair return? Yet how many companies spend thousands of dollars every year for employe publications and casually excuse the house organ from obedience to the economic facts of life? Who's to blame? Many communications experts place the blame squarely on management's shoulders. In too many instances, they claim, management actually won't let employe publications do a good job. As one put it: 'Many employers give the impression of insincerity in telling their stories, use ineffective methods, inform employes too late, or never get around to informing them at all.'"

Summers quotes a union officer's criticism of company magazines: "When we look through the papers and magazines published for employes by corporations of this country, we find that they omit mention of any of those concerns which the workers consider so vital . . . I wonder how the editors of the papers or the owners of the plants can expect their employes to have confidence in anything a paper says when the paper ignores the basic problems in which the worker is concerned."

Industry had better pay attention to words like these.

Union Papers Inform. It doesn't take much study of union publications to see that these papers don't ignore what *they* consider to be "the basic problems in which the worker is concerned." Systematically, and on a nation-wide scale, they're pulling out all the stops in a formidable effort to influence the thoughts—and the votes—of American workers.

The union publications don't worry about entertaining readers. They leave that to others. They haven't the time or the space. They know that the employe wants knowledge. So they give it to him—spoon-fed "knowledge" that turns the employe's loyalties to his union rather than to his company. Whether discussing the "exploitation" of the worker by the company, or blasting at the "perils" the employe faces if a labor bill passes Congress, the union publication endlessly shouts that unionism alone is the true champion of the worker.

And the employe publication, with a matchless opportunity to tell the other side of the story—simply by stating facts, not by fighting falsehood with falsehood—too often misses the boat.

Employes Understand Little. The most curious aspect of this dilemma is that in spite of their errors, members of business management in America have set an outstanding record of achievement in advancing the best interests of their employes. Yet surveys have consistently shown that those employes, and the public as well, often display low opinions of business and businessmen. The average American, it must be admitted, is perplexed about labor-management issues; he doesn't quite trust big business, though he may earn his wages in a big company; he understands very little about basic economic factors such as capital and profits; and he often fails to recognize that his job security, his prosperity, and the comfort of his future years depend directly upon the progress and success of industry.

These are the things employe publications should be talking about—the things the better publications are beginning to talk about. This is the fertile field in which prudent managements and imaginative edi-

tors have their work cut out for them.

But where does the oil industry stand in this picture?

Many oil companies are among those businesses which have been re-evaluating their communications programs. Several "majors" have publicly announced their intention to stand up and talk articulately about what they are and what they believe in. In all types of media—newspaper releases, bulletin boards, radio and television, employe meetings, and in their now-evolving employe publications—they are beginning to act.

Why? Self-preservation, for one thing. Take a look at some of the areas in which the oil industry has been the target of bitter political debate:

- Percentage depletion
- Price competition curbs
- Imports of foreign oil
- Controls on state production
- Natural gas bills
- Administered prices
- Tidelands oil
- Pipeline "monopolies"
- Divorcement

These are complex, controversial, often abstract subjects. They are hard to understand and harder still to explain simply. But they are not beyond the interest range of the average employe. On the contrary, polls reveal that employes are convinced they will be personally affected by the outcome of many of these issues. They are interested in receiving factual information about them.

Deal In Specifics. Management is playing head-in-the-sand if it pretends the issues don't exist, or that their employes ignore them. The companies which have decided to take a stand are discussing these subjects articulately and intelligently. They state the company's—and the oil industry's—position, and let the reader decide what he believes. They deal in specifics: they urge the employe to vote at election time, but they also discuss campaign issues in the light of their effect on company and industry progress—and leave it to the reader to make up his mind.

Nevertheless, in many companies a great deal remains to be done before their employe publications measure up to their possibilities.

Here are four actual incidents which occurred within recent months in major oil companies. They point to the internal problems which managements must solve before their communications programs become really effective.

1. "Training Tool." An employe magazine editor visited a field district office to get acquainted with the new district manager. The official had been employed by the company for more than a decade, working in several parts of the country. A geologist by education and background, his primary job was to find oil for his company. He had a staff of 35 people.

The editor introduced himself, then discussed briefly his past efforts to cover the activities and operations of this district. He mentioned that a capable correspondent in the office was a frequent contributor of news items for the publication.

"I'll do all I can," the editor said, "to see that your district continues to be adequately represented in our magazine."

The new district manager grinned, then threw this back at the editor he'd just met: "Bill, don't bother me with this stuff. You know as well as I do that employee publications are nothing but tools of the safety and training people. That's all there is to it." Despite the grin, he obviously meant it.

The editor, a younger man with considerably less company service, was stunned at the statement. But he passed it off as a joke and soon ended the discussion on a harmless note.

A more dedicated or articulate editor would probably have jumped at this opportunity to set the district manager straight—politely—regarding the precise objectives of the publication. Instead, he let the chance pass by—and in so doing, let the misinformed manager win the round. More regrettably, the manager's low opinion of the value of employe publications has probably rubbed off on many of the people working for him in the past, and will continue to do so. Just imagine the task the editor will have in getting worthwhile news from this manager's territory. And consider the job top management will have should they undertake a systematic, organized program of educating their personnel in the real value of communications.

2. Don't Care. In a large refinery, two members of middle management were discussing employe publications. "I suppose some of our employes like them," one mused, "but personally, I think you could do away with all of them and most people wouldn't care very much. Take a pipefitter out in our plant: he's interested in his immediate job, in the group of men he works with and plays dominoes with at lunch, in his wife and kids, and in his motor boat. So long as he does his job during that eight-hour shift, that's all he's concerned with. Our people don't understand anything about percentage depletion or imports or what January's allowable is. And frankly, they don't give a hoot about them. So why put these things in the publication which the men hardly read anyway?"

This man believes he knows his plant's employes. But repeated surveys prove he is not speaking for the majority of them if he thinks they have no interest in their company beyond the weekly paycheck, or in the vast problems facing the petroleum industry.

Perhaps this executive's opinions would be relatively harmless if he were, say, stuck away in a research department somewhere. But unfortunately, one of this man's duties is actually supervising the editor of his company's magazine. What chance does that editor have to break the "silence barrier?" How far can he go, even if the refinery's top management is sold on good communications, until his supervisor's opinions are drastically revised . . . or a new supervisor takes his place?

3. No "Poor Boys." During the recovery last spring from the low-profit months of 1958, one enterprising oil company editor went to his boss with a proposal. "Let's do a picture-story on cost-consciousness," he said. "Here's the suggested copy and a couple of layout ideas. We can list the annual savings to the company if every employe uses his pencils just a little longer, or saves paper clips instead of discarding them, or prac-

tices other minor economies. Even though business is better now . . ."

His boss cut the proposal short. "The idea has merit," he said smoothly. "But look, we're not a poor-boy outfit, and we don't want to give anyone the idea we pinch pennies. What's another inch or so on a pencil? Why don't we table this one for a while?"

The editor might have sold his idea had he presented it from a more imaginative point of view. But it's not likely. This boss could not see that pennies add up to dollars. And so another opportunity made to order for the worthwhile company publication was passed by.

4. Zone of Silence. An oil company was in the midst of union negotiations last summer. The editor of the company magazine suggested a comprehensive article on the negotiations. He would state both the company's and the union's positions on the issues involved, giving the workers for the first time a clear explanation of the company's viewpoint as opposed to the one-sided information they'd received in their union literature.

"I know we've never covered union news before," the editor told his boss. "But I believe it's time we did. We can work out an approach which will be completely fair and accurate, and it will serve a worthwhile purpose."

He was turned down. Devotion of that much space in the magazine, said his boss, would lend too much prestige to the union.

"If we just ignore them," he said, "we'll be better off."

The silent treatment again. This manager will never know how many of his employes might have had their convictions shaken a little, how many might have felt some disillusionment with the "cause," had the magazine done a forthright job of covering the issues being discussed.

Let it not be said that the companies mentioned in these four examples are typical. But unfortunately there are many like them, having among their management and supervisors, employes to whom communications is a meaningless word.

A Vigorous Stand. Fortunately, as stated earlier, many companies are beginning to take a stand, and a vigorous one, in their publications. In an address before the fourth annual Oil Editors' Conference in Austin, Texas in 1958, Robert L. Klaus, editor of *Our Sun,* said of Sun Oil Co.:

"We don't believe there is a place in our magazine for articles—no matter how pleasant it might be for the editors to work on them—the purpose of which is to entertain, or for generalized articles which our readers can find—and find so much better done—in the general-circulation magazines. We do believe we have a very specific job to do, that it is a job which needs doing and a job which nobody can do nearly as well as we can. That job is interpretation—interpretation of our company, our industry, our management, our activities, our employees, our philosophy.

"Nowhere else can our readers get that information as we can give it to them. Nowhere else can the employe learn so much about the things which mean so much to him—his company, his management, his supervision, his job, his benefits, his security—the environment in which he spends one-third of his life, one-half of his waking time."

Let Editors Write. Fred Foy, President of Koppers Company, Inc., has some ideas along these lines which we should certainly consider. He says, " . . . management of large corporations or companies which usually support an employe publication program should be willing to let the editor of the company publication write the material as simply and understandably as the unions are doing it. A good many companies will 'committee' this one to death, between company economists, the legal department, the finance department, and last but not least, the president's office. It is perfectly amazing how persuasive many business men can be on this kind of a subject until they either try to write it out or discuss it in a prepared speech.

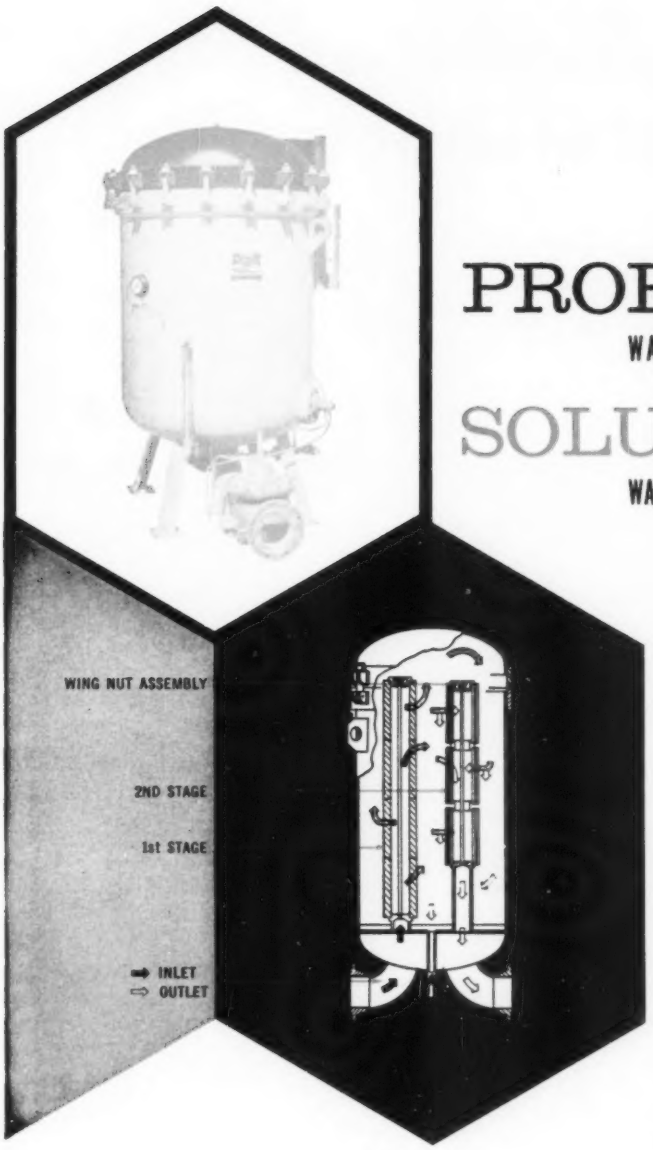
"Once it has been decided that the editor is to do the writing, then the necessary editorial calibre should be provided. This important kind of thinking and writing calls for editorial skills far beyond the 'picnic and bowling team' kind of writing being done in many employe publications.

"Then last, but not least, management should be willing to face up to the fact that material of this kind must be presented forcibly and with conviction. As we have seen, labor does not hesitate to present its own side of the argument on many of these economic and political problems. Management feels that a more objective picture that presents both sides is fairer and perhaps more convincing. Maybe, but that doesn't mean it shouldn't present its own arguments and present them with spirit. Most people, including workers, respect honest enthusiasm. And, many like a good battle, even if it's only a battle of words and ideas."

In addition, Foy has outlined these suggestions which each member of the management team should consider if he expects his organization's employe publication to achieve maximum success and effectiveness as a company spokesman.

1. Charge your editor with making this job a part of his editorial plan.
2. Do all you can to help him get the facts, but let him see to the writing and editorial work.
3. See that he gets every union publication reaching your people as well as the official national organ of the AFL-CIO. He needs to know what he's up against and how well they are doing the job.
4. Send him to talk to key people in national organizations that are working to tell the story of free enterprise. He needs a working knowledge—a personal point of reference. He needs to know what these organizations are doing, what they have done, what they are publishing that will help them do a better job. Among them are the National Chamber of Commerce, the National Association of Manufacturers, the National Industrial Conference Board and others.
5. Supplement your employe publications with other in-plant communications—the bulletin boards, the reading rack, letters to employes, and so forth.

With such steps as a start, the communications program can gain speed—and stature. And the employe publication can begin to do the job which will justify its existence. ##



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1st Stage **Coalescing-Filtering**
Hydrocarbon and water enter inlet and pass through the coalescer cartridges where solids such as dirt, rust and scale are removed and mechanical emulsions are broken. Finely dispersed water droplets gather together into large water droplets and fall by gravity into the water-collecting sump.

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Clean hydrocarbon and any entrained water droplets flow to the separator cartridges. This chemically-treated media completely blocks the passage of water and clean hydrocarbon passes through the cartridges to the outlet.

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Test Yourself on Labor Relations

No. 1. Visits by Union Official

Max Winkle was a business agent for a union. It was his practice to visit the premises of the employer in order to handle employe grievances. During one of his visits he got into a verbal tiff with the president of this small company. He raised his voice and even walked around the desk and talked into the boss's face.

"Don't you come around here any more," the boss said. "I don't want any such fresh guys like you around here."

"I represent these employes and you can't keep me out of here," Max hollered.

When Max showed up the following week, the boss called the police and had Max escorted to the gate. The union took the case to arbitration on the grounds that the employer must permit access to union representatives if the contract is to be properly carried out. It argued that if Max is barred, then the employer can do the same to others and thus stymie the processing of grievances.

Test Yourself:

Was the union RIGHT ☐ WRONG ☐

No. 2. Job Seniority

John Kelso was a 7-year man. He got an offer from another company and took it. But that job didn't work out so he returned to his original outfit as a new hire. While he was on probation, a job vacancy opened up and Kelso, together with 3 other employes applied. Of the 4 applicants Kelso had the most experience. He had done that kind of work before while the others would have needed some training in order to meet standard.

The foreman picked Kelso on the grounds that his experience was so superior that he couldn't be overlooked. The company had a policy which read: Seniority will apply in filling new jobs, vacancies, transfers, layoffs, recall from layoff. The employe must have the ability to meet the job requirements. In applying the rules of seniority set forth herein, due measure of regard shall be given by the company to the following factors:

1. Seniority

2. Qualifications and ability

3. Physical fitness in meeting the job requirements.

Where all such factors are relatively equal, the employe with greater seniority will be given preference.

Management maintained that Kelso's ability was so far above the others that seniority was not a factor to be considered.

Test Yourself:

Was the company RIGHT ☐ WRONG ☐

No. 3. Reporting for Work

John Gregg phoned his foremn and said he would be absent. When the foreman asked him "why," John answered, "Oh, some family problems."

"When are you coming in?" the foreman wanted to know.

John replied that he would return to work "just as soon as possible." He didn't show up for 5 days in all, and when he came to work he was told that he was discharged for excessive absenteeism.

"You can't do this. The company rule says that a worker must notify the company when he expects to be absent. This I did. I'm covered," John argued.

The management didn't budge from its position. It held that:

1. John was out for 5 days. The company rule was that an employe loses his seniority if he is absent for 5 days without notifying the company.

2. A telephone call saying that he would be back as soon as possible was not proper notification.

3. Family trouble was not an acceptable excuse for a 5-day absence.

4. John's absentee record was "bad."

Test Yourself:

Was the company RIGHT ☐ WRONG ☐

Answers on Page 322

Series:
NEW
Masoneilan 20000 Series Control Valves
The Most Versatile
Single Seated Valves Available
With this new line Mason-Neilan offers a single seated, solid-cast design with outstanding advantages; engineered expressly to meet requirements of modern process and power plant applications; a premium valve without a premium price.
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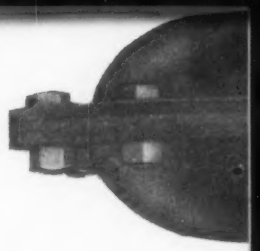
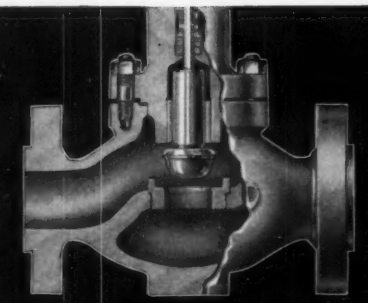
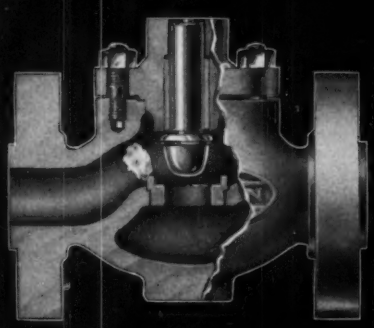
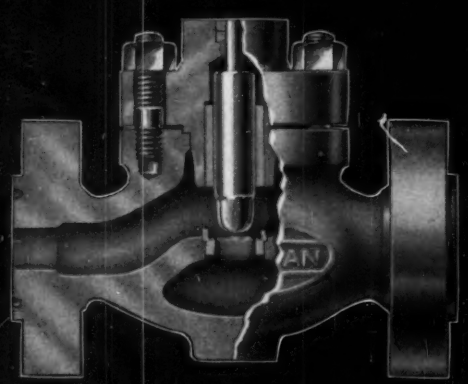




Two inch, 600 body with full capacity plug.



Two inch, 1500 body with full capacity plug.



Two inch, 2500 body with full capacity plug.

With the introduction of this new line of solid-cast control valves the advantages of single seat design become available for a substantially wider scope of application, from the simple to the most severe. Consider these premium features built in as standard, available to you at no extra cost.

• **High Capacity** — top guiding, unrestricted seat ring area, body and plug contours provide greater capacity than most top-and-bottom-guided double seated valves of comparable sizes.

• **High Pressures and Pressure Drops** — high capacity is attained with minimum seat ring areas, resulting in less unbalance force, permitting higher pressure drops. Heavy guiding throughout full stroke results in a minimum of unsupported plug length and allows high pressure and high pressure drop applications without lateral vibration. Generous guide surfaces and large plug stems are sized in accordance with body rating.

• **Wide Selection of Reduced Capacity Trim** — for those applications where velocity due to high drop is a consideration (or where future requirements for larger capacity are a factor) a wide selection of reduced capacity trim is available — and interchangeable in comparable valve sizes and ratings (see table). The proper relationship between stroke and trim size is maintained in order to provide the strongest possible plug tip, particularly in hard, brittle materials.

Valve Size	Available Cv Ratings										
¾	1.5	3.4	5.2	8							
1	1.5	3.4	5.2	12							
1½	1.5	3.4	5.2	12	25						
2	1.5	3.4	5.2	12	25	46					
3				12	25	46	110				
4					25	46	110	195			
6						46	110	195	400		
8							110	195	400	640	
10								195	400	640	1000

P. O. MN0-1

Two inch, 600 lb. valve has size 11 actuator.

Two inch, 1500 lb. valve has size 13 actuator.

Two inch, 2500 lb. valve has size 15 actuator.

Wide Selection of Materials — the design of body and plug permits the use of suitable special materials to meet severe operating conditions.

Suitable for Slurries — body and plug contours (plus the fact that no bottom guiding is required) make these valves suitable for viscous fluids and slurries.

Welding Ends Available — the solid-cast body allows the use of welding ends. The removable bolted bonnet permits easy (only one joint to break) inspection or cleaning with valve in the line.

Actuators Sized to Body Rating — the standard spring-diaphragm (direct or reverse) actuator is sized according to body rating, thus minimizing requirements for oversize actuators in severe applications. Where extra high initial or final thrust is desirable, the judicious selection of actuator size and spring range enables the spring-diaphragm actuator to be used in most instances. For applications beyond the scope of the spring-diaphragm type, springless-diaphragm, cylinder or electric drive actuators are available.

SPECIFICATIONS — **Sizes:** ¾", 1", 1½", 2", 3", 4", 6", 8", 10"

Ratings: Steel — 150, 300, 400, 600, 900, 1500, 2500 lb. ASA
Iron — Class 125 or 250 ASA

Connections: Screwed ends — ¾"-2" in 600 lb. and Class 250 rating
Flanged — ¾"-10"
Welding ends available on steel valves.
Face-to-face dimension is I.S.A. standard.

If you are concerned with control valve selection, it will pay you to investigate the high performance, low cost 20000 Series. Get in touch with a Mason-Neilan representative or write

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How to Do It...

Slide Rule Trick Gives Fourth Place

Finding an additional significant figure on a conventional slide rule ordinarily involves a considerable amount of guessing. This method always gives it to you accurately

There is a convenient method for obtaining an additional significant figure on your conventional slide rule. Assume you have a value on the D scale as a result of some calculation, say 114 × 3.8, which by ordinary methods you can read as "about 433." There would be a considerable doubt in guessing the fourth significant figure.

To find the fourth figure, set the slide hairline to the D scale value. Then move the C scale so as to find two small graduations on this scale whose distance is exactly equal to the distance between 430 on the D scale and the hairline.

There are three cases that will work in this example, as shown in the figures. Figure 1 shows a case where five units on the C scale match the distance in question on the D scale. This distance on the C scale is 670 to 675. To find the fourth significant figure, read 3.2 on the D scale opposite 5 on the C scale; or the four-place product of 114 × 3.8 is 433.2.

Figure 2 shows a case where the graduation distance between 430 and the hairline is two units (368 on C opposite 430 and 370 opposite the hairline). By reading the D scale opposite 2 on the C scale, the value of 3.2 can again be read for the third and fourth significant figures.

Figure 3 illustrates the case where the matching graduation distance on the C scale represents one unit on the D scale (134 on C opposite 430 on D and 135 on C opposite the hairline). The value of 3.2 on the D scale is read opposite 1 on the C scale.

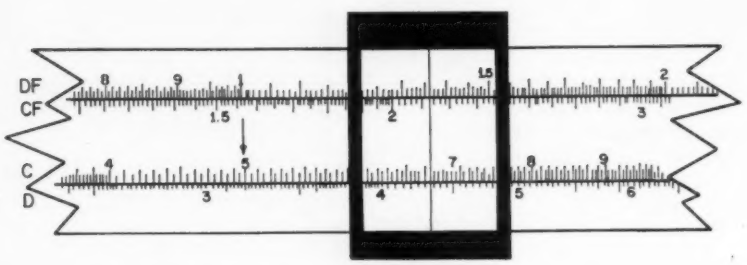

FIGURE 1

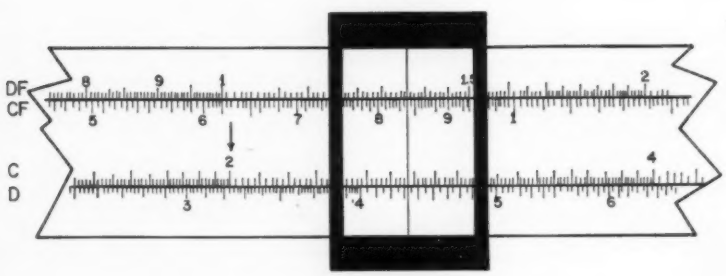

FIGURE 2

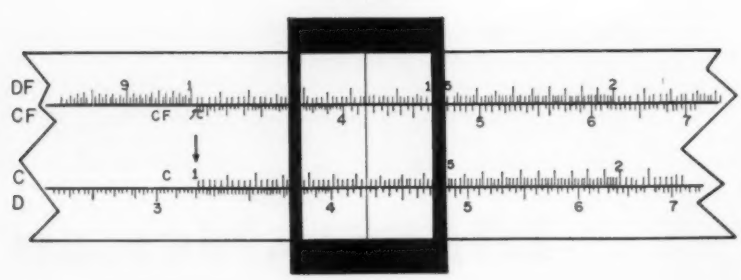

FIGURE 3

The principle of this method is simple. As to Figure 1, assume the value under the hairline on the D scale to be X. Then,

$\log 675 - \log 670 = \log X - \log 430$

or $\log (675/670) = \log (X/430)$

Therefore, $675/670 = X/430$

By rearrangement,

$$X = (675/670) \times 430 = (5/670 + 1) \times 430$$

Therefore,

$$X = 430 + (430/670) \times 5.$$

Since 670 on the C scale has already been set to 430 on the D scale, the reading on the D scale opposite 5 on the C scale is 3.2 or is the value of $(430/670) \times 5$.

Therefore, $430 + 3.2 = 433.2$.

This idea was submitted by Shou Chen Ting, Taipei, Taiwan.

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The table lists Alloy Casting Institute symbols for the nickel-alloy corrosion resisting castings, along with their nearest AISI wrought stainless steel counterparts.

ACI	AISI	ACI	AISI
CE-30	312	CF-8C	347
CF-8	304	CF-16F	303
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		CN-7M	—

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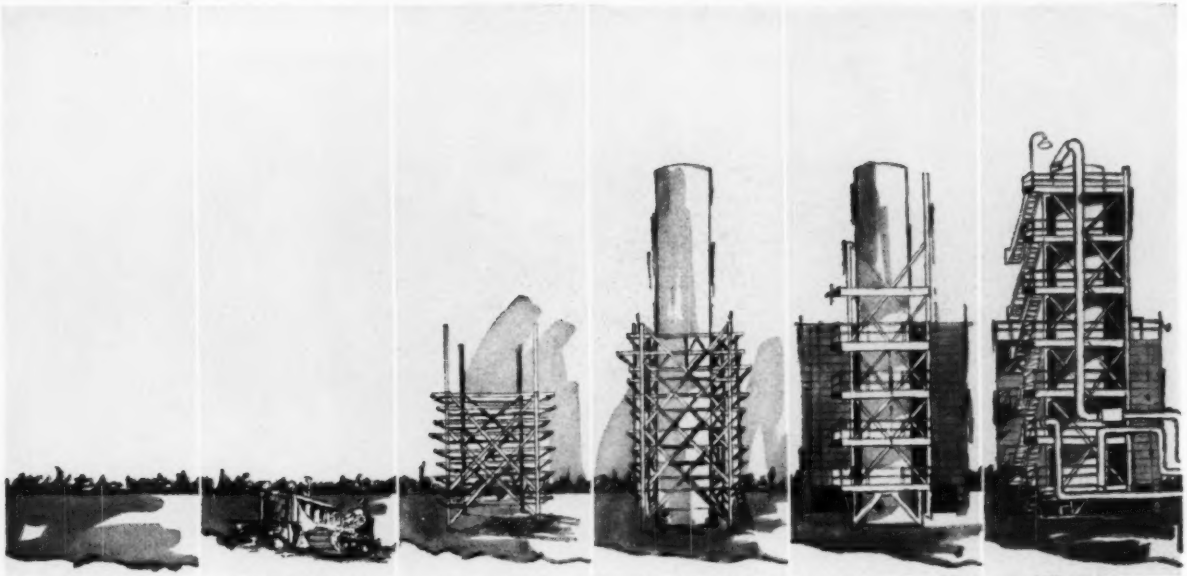

It took just six months for Chemico to successfully complete a 120 ton per day nitric acid plant in Lawrence, Kansas. Until the client gave his final "go-ahead," not an hour of drafting or engineering had been done on the project—not a single piece of equipment had been placed on order. Yet, six months from that date, the plant finished its acceptance test run, producing at above rated capacity.

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How To Do It . . .

Check Studs for Temperatures Above 500°F

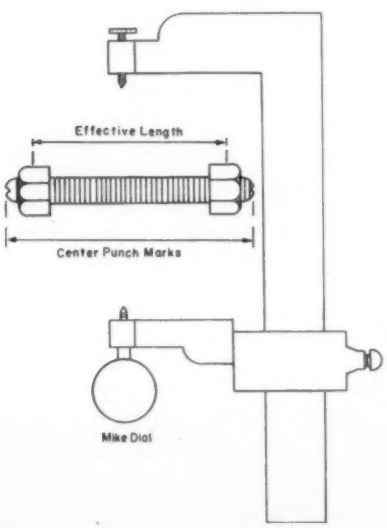
TABLE 1—Stress, Torque and Elongation of Typical Stud Bolts

Size Of Alloy Steel Stud Bolt	Average Stress Manual Application, Lbs. Per Sq. In.	Approximate Torque To Develop Stress Ft. Lbs.	Elongation In Inches, Per Inch Of Effective Length
¾	52,000	175	.00173
⅞	48,000	255	.00160
1	45,000	370	.00150
1⅛	42,500	500	.00142
1¼	40,000	665	.00133
1⅜	38,000	860	.00127
1½	36,500	975	.00122
1⅝	35,000	1285	.00117
1¾	34,000	1700	.00113
1⅞	33,000	2200	.00110
2	32,000	2350	.00107
*1	*2	*3	*4

The values stated in the table were graduated by ASTM according to size. Should a higher bolt stress be required, and it is possible to apply the torque, the stress should be approximately 45,000 psi.
* 1. Coarse thread series, 1 inch and smaller; 8 pitch thread series, 1¼ inch and up.
* 2. The average stress applied manually in tightening, employing a lever and wrench, and/or sledging.
* 3. Well lubricated threads.
* 4. Based on the modulus of elasticity of 30 million. The stud bolt effective length equals the distance from the center of one nut to that of the next.

One plant has a rule that bolting in all flanged joints operating at temperatures above 500° F must be tightened after the initial shutdown. It was found that on high temperature service where creep is a possibility, it is wise to pull the bolting up at least once during the first 200 hours of service on the high temperature lines, regardless of whether the line has been shutdown or not. Bolt stresses must be checked at regular intervals after installation.

Normally it is only necessary to measure the elongation in two or three diagramatically opposite stud bolts, using the average of the values obtained as the elongation for the balance of the bolts. Should the elongation measurement be made while the joint is in service, one bolt must be measured and pulled up before another is loosened. The measurements should be taken immediately after releasing the load before the bolt temperature lowers.



The following procedure is recommended in checking bolt elongation:

- Measure the length of the bolt in the assembled joint.
- Reduce the stress on the bolt by loosening the nut, and again measure the bolt.
- Subtract the second reading from the first.
- Divide the result by the effective length of the bolt.

The figure illustrates a type of caliper that can be made up in the average shop to measure stud bolt elongation, plus the technique of punch marking the bolt ends.

Note: The effective length equals the distance from the center of one nut to the center of the other.

Should the residual elongation be less than 70 percent of the values in Table 1, the bolts should be tightened up to where the final elongation is in close approximation to the values stated.

Erectors have a choice of two methods for applying the initial bolt stress. They are: (a) Using the right torque to pull up well oiled threads. (b) By tightening the stud bolts to develop the stretch necessary for the required bolt stress.

If the second method is elected, the total required elongation of the stud

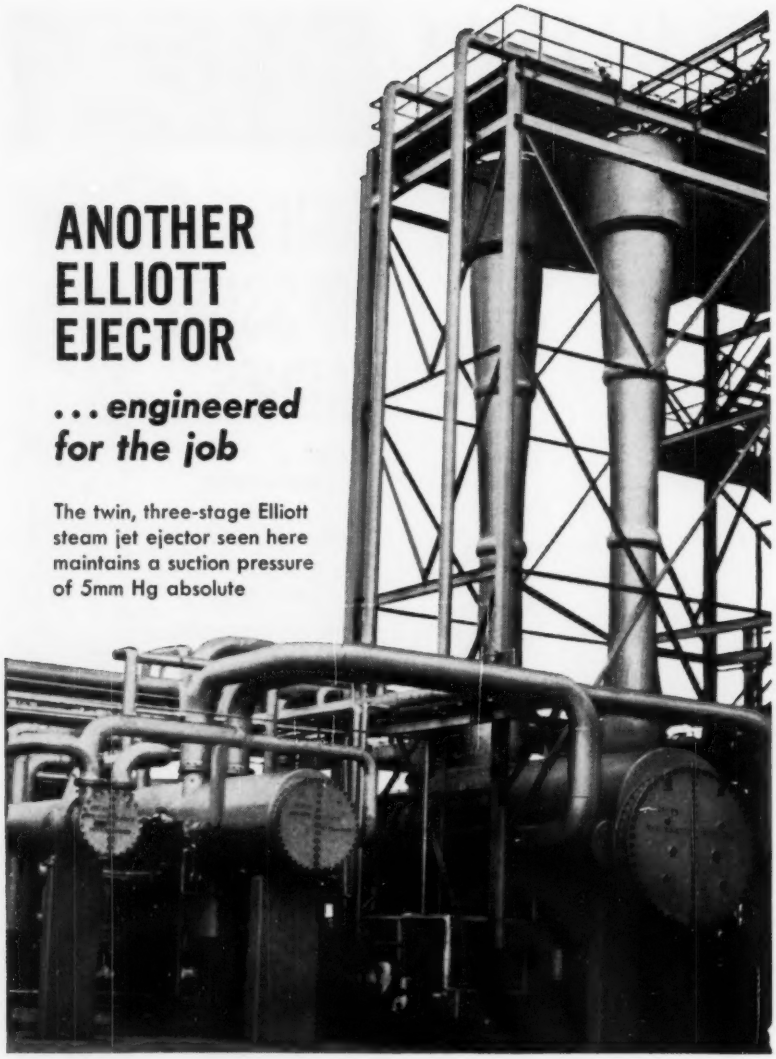
Strahman
HIGH PRESSURE GAUGES
USED IN REFINERIES AND CHEMICAL PLANTS THROUGHOUT THE WORLD
THRU VISION
REFLEX
Single or Multiple Sections
TUBULAR
Gauge Cocks
•
Large Chamber Reflex Gauges
•
Heated or Cooled Gauges
SEND FOR COMPLETE CATALOGUE
STRAHMAN VALVES, Inc.
NICOLET AVE., FLORHAM PARK, N. J.

For more data on advertised products, use Readers' Service Cards, last page.

ANOTHER ELLIOTT EJECTOR

...engineered for the job

The twin, three-stage Elliott steam jet ejector seen here maintains a suction pressure of 5mm Hg absolute



designed to serve world's largest crude oil unit

This unique, giant-sized ejector is the largest vacuum installation ever built. The design problem here was to engineer a unit which would efficiently and economically maintain the specific suction pressure required by the application. To accomplish this, Elliott engineers designed a twin-type ejector with two vertical first-stages which are 40 ft long, have 60-inch diameter inlets, and discharge to a 20,000-sq ft intercondenser. The two 20-inch second-stage ejectors discharge to a 6000-sq ft intercondenser and the third-stage ejectors discharge to a 3000-sq ft aftercondenser.

write us for descriptive bulletins

Available literature on single-stage, multistage and corrosion-resisting types illustrate Elliott's versatility in ejector design and construction for all sorts of chemical and industrial process applications. Contact your nearby Elliott District Office or write Elliott Company, Jeannette, Pa.

ELLIOTT Company

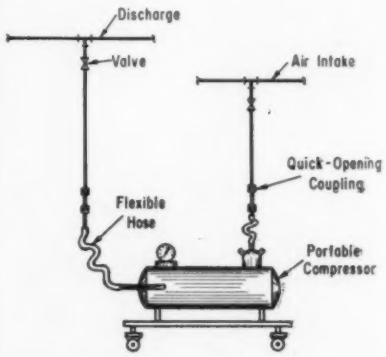
Send for complete details today

GE-2

How To Do It . . .

bolt must be determined by multiplying the value in the table for elongation in inches per inch by the effective length—expressed also as the distance from the center of one nut to the center of the next.

This idea was submitted by Paul C. Ziemke, Clinton, Tenn.



Portable Air Compressor Used for Shutdown Load

Frequently, available compressed air supply is not adequate to satisfy plant needs for short periods of time. This usually leads to installing additional facilities for these peak periods, requiring a large capital investment for compressors, accessories and foundations.

One method that can minimize expense, is to provide a portable compressor, details of which are shown in the figure. The mobile unit is pulled to the required location and connected to the existing intake and discharge headers by means of flexible metal or rubber hose. The latter are provided with quick-opening couplings of which several variations in design are available. Shut-off valves are installed to isolate the respective systems when not in use.

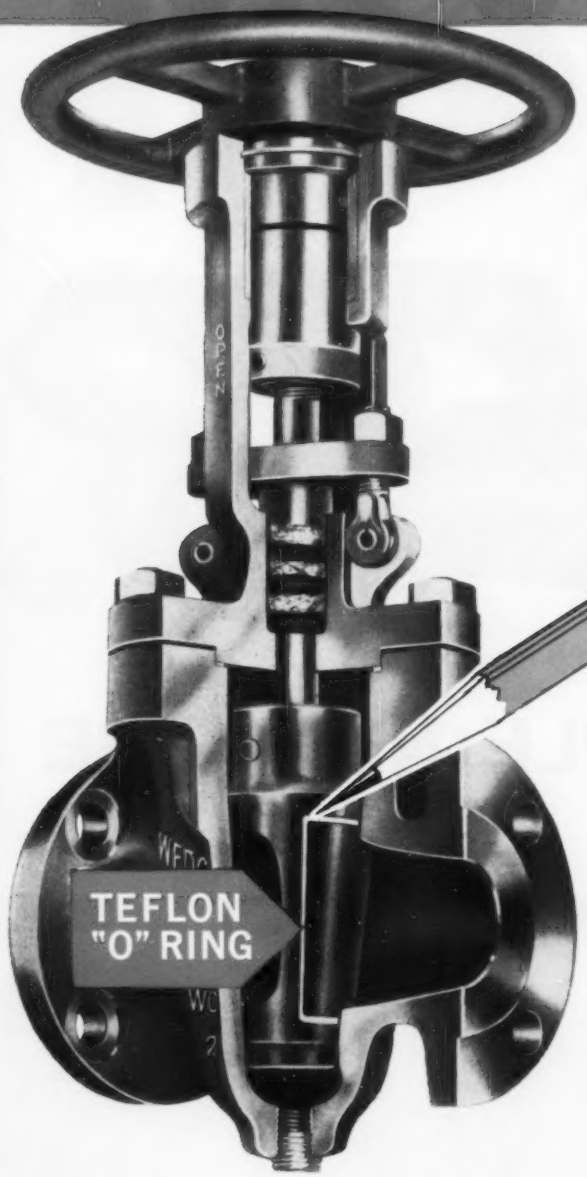
This arrangement offers flexibility and permits the compressor to be moved wherever needed, without requiring foundations, receivers, etc. Special tools and skilled labor are not necessary to make the system operable. In addition to providing a temporary source of compressed air in different areas of a building, the arrangement also offers this facility to other buildings and work areas throughout the plant site.

This idea was submitted by H. B. Wayne, Woodhaven, N.Y.

For more data on advertised products, use Readers' Service Cards, last page.

This bubble-tight seal

can't cause contamination... costs nothing to maintain!



Stockham's NON-LUBRICATED Wedgeplug*'O-SEAL' Valve

Meet the valve that gives you permanent, absolute shut-off without sealing compounds or lubricants. The valve that eliminates the danger of contamination resulting from excess lubricant being forced into the product stream. Eliminates the danger of product mixing in manifolds.

The valve is Stockham's NON-LUBRICATED Wedgeplug "O-Seal" — now widely used in general purpose services. Two Teflon† "O" rings in the plug provide the pressure-seal—provide permanent "bubble-tight" shut-off in all cases.

The "O-Seal" is guaranteed not to stick... provides double-block and bleed in most services... has flawlessly machined metal seats to provide shut-off in case of fire.

*Patented — †Teflon, Dupont Trademark

Call your Stockham Distributor or Sales Representative now, or write Stockham for complete details about the "O-Seal."

Complete ranges of sizes and types available.

CAST IRON-MALLEABLE AND DUCTILE IRON PIPE FITTINGS—BRONZE, CAST IRON, DUCTILE IRON, CAST AND FORGED STEEL VALVES.

SOLD ONLY THROUGH DISTRIBUTORS

WEDGEPLUG VALVE COMPANY

Division of

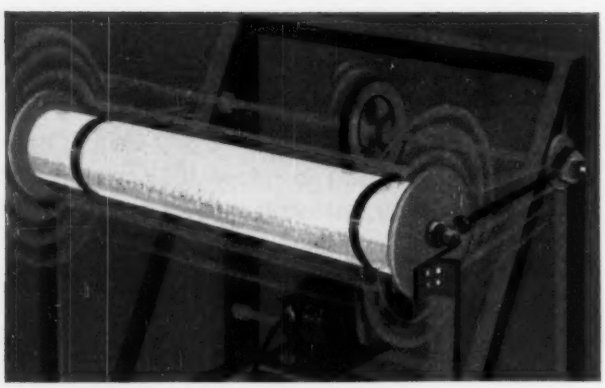
STOCKHAM VALVES *and* FITTINGS

General Offices and Plant

4000 North 10th Avenue • Birmingham 2, Alabama

K&M ZEBRA

THE REMARKABLE NEW PIPE



ZEBRA withstands vibration! In this rigidly constructed test, ZEBRA proves it is able to withstand intense vibration without cracking or abrading.

ZEBRA won't warp or crack! "K&M" tested ZEBRA to simulate working conditions in which equipment would be used.

And, neither will ZEBRA crack or warp under heat.

for temperatures of 200°F to 1200°F

Remarkable new "K&M" ZEBRA is a low, medium, and high-temperature pipe insulation, available sectionally in a wide variety of pipe sizes and thicknesses.

It has come through with flying colors in tests conducted by both "K&M" engineers and an independent testing laboratory.

These tests prove that "K&M" ZEBRA withstands shock and heat without warping or cracking. It's quick and easy to handle and install . . . with minimum loss due to breakage. In addition, "K&M" ZEBRA meets your requirements for density, conductivity, modulus of rupture, and the ability to withstand soaking heat.

"K&M" ZEBRA is a multi-layer sectional-type thermal insulation primarily composed of calcium silicate-asbestos fiber bonded felts. It's the result of long "K&M" experience in the manufacture of high- and low-pressure insulations, pipe and block insulations, cements, and textiles.

More information on this years-ahead insulating material is now available. Write to us today.

RA INSULATION

K·M BEST IN ASBESTOS

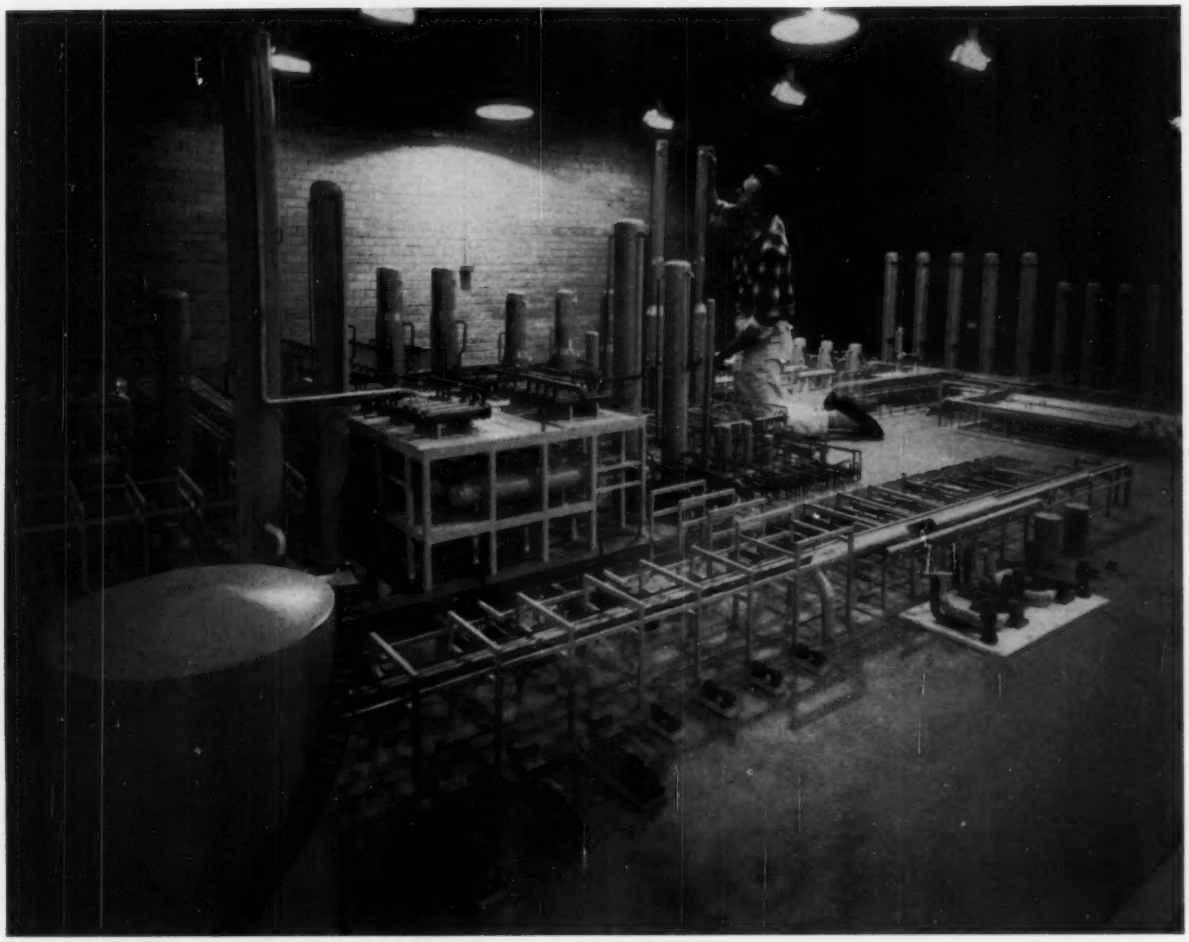
KEASBEY & MATTISON
Company • Ambler • Pennsylvania

ZEBRA is made in the larger pipe sizes in half sections which will speed application and reduce number of joints. Keeps installation costs way down!

ZEBRA won't cause skin irritation! The smooth surface of "K&M" ZEBRA prevents both the irritation of the skin and its penetration by ragged projections.

For more data on advertised products, use Readers' Service Cards, last page.

Who's Building...



Craftsman puts finishing touches on model of King Ranch gas plant. Model was built by Escavath Co., Houston.

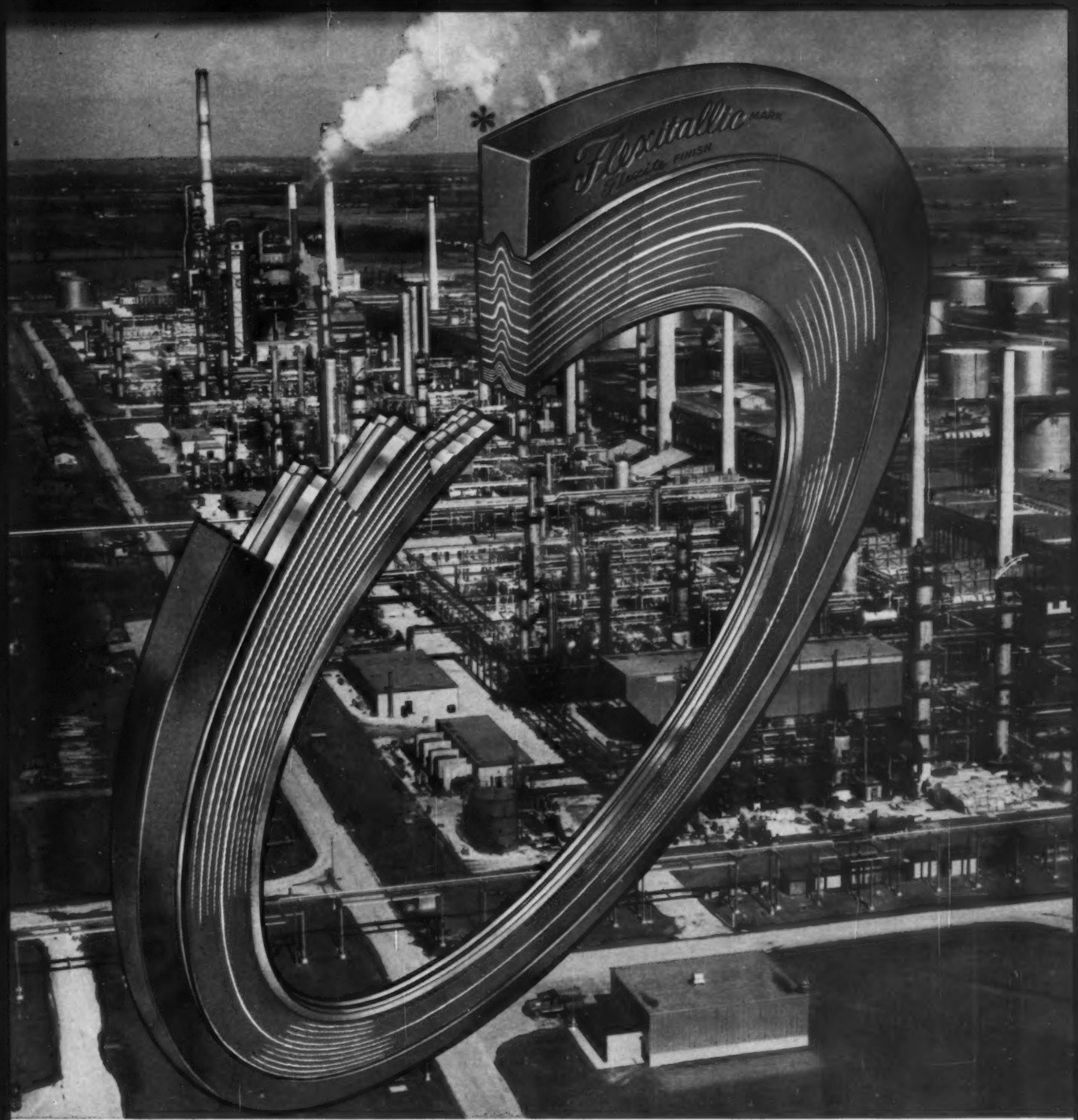
Big Is the Word for Humble Gas Plant

New $70 million, 800-MMcf-per-day unit is being built by Hudson. It will be on stream this summer

Almost completed and ready to come on stream is the last phase of Humble Oil & Refining Co.'s $70 million natural gas processing project for the Southwest Texas area—a gigantic gas plant on the huge King Ranch in Kleberg County, near Kingsville, Texas. The 800-MMcf-per-day plant, which is the largest gas processing unit in the United States, has been underway with construction for several months. Located 14 miles southwest of Kingsville, the processing giant will recover approximately 28,000 bpd of liquid products when completed this summer—probably in June or July.

The unit, which is being engineered and constructed by Humble Oil & Refining and Hudson Engineering Corp., Houston, will include gas lines extending into several oil and gas fields, the main gas processing and cycling plant, and a 238-mile, 30-inch pipe line from the plant to Houston.

Already completed on the King Ranch project are initial cycling operations. Liquids from these operations are being recovered by normal separation. Separator gas is then compressed by seven 2,000-hp compres-



End corrosion in gasket inventory

The gold Flexite Finish* for the metal gauge rings in Flexitallic Compression-Gauge Gaskets is new. It is highly corrosion resistant when exposed to severest weathering in open construction projects or in stock. The Flexite Finish provides for ease of identification and a clean, long-lived installation. Write for samples.

FLEXITALLIC GASKET CO., 8th & Bailey Sts., Camden 2, N. J.
Representatives in Principal Cities

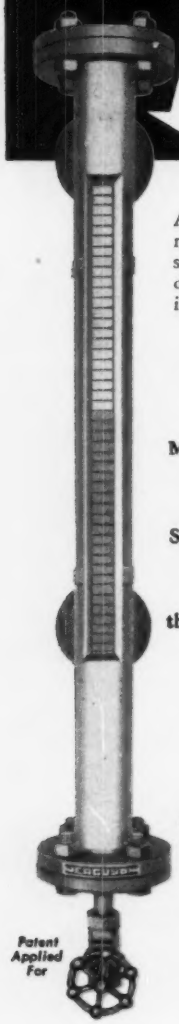
TRADE Flexitallic® MARK
SPIRAL-WOUND GASKETS
WITH Flexite FINISH

*The gold Flexite Finish is a development of the Flexitallic Gasket Co. (Originators of Spiral Wound Construction) — Register applied for on both name and color. Flexitallic Blue is our exclusive blue-dyed Canadian asbestos filler. Look for the blue and gold color combination as the mark of Flexitallic quality.

the New Jerguson

MAGNETIC GAGE

for liquid levels



An important advancement in liquid level observation for plants with dangerous explosive or inflammable conditions.

Safety design seals against escaping gases.

Measuring mechanism in stainless steel chamber.

Scale mounted outside chamber; magnetically actuated through chamber wall.

Distinct, accurate level shown in red contrasted with silver above.

Job designed, correlating pressure, temperature, and specific gravity.

Available with electric alarms.

Can also be used for interface indication.

Patent Applied For

Write now for engineering sheet on Jerguson Magnetic Gages.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Adams Street, Burlington, Mass.

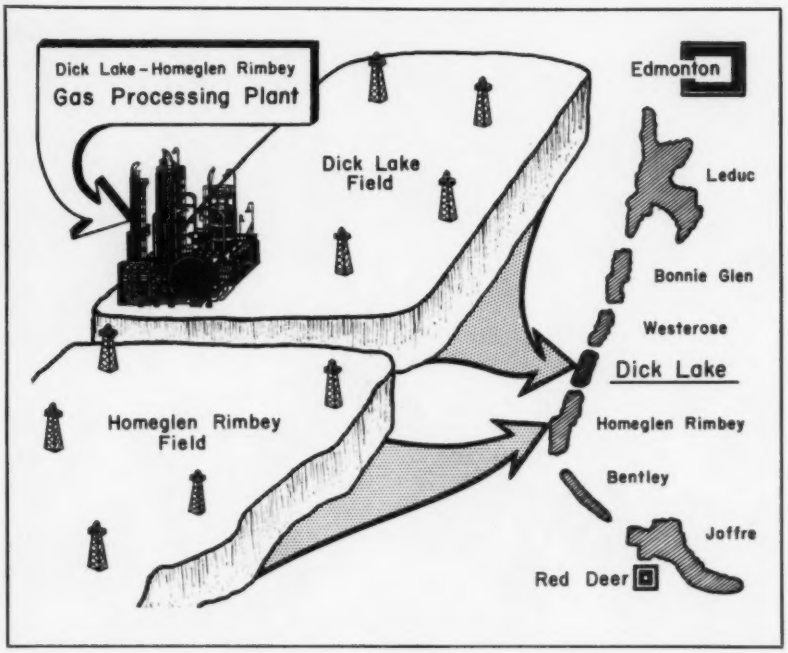
Offices in Major Cities

In Canada: Peacock Bros. Ltd.

Building . . .

sors for injection into producing reservoirs.

Concrete foundations for the various unfinished units have been poured, and major equipment is arriving rapidly.



B-A to Operate New Alberta Gas Plant

British American Oil Co. will operate a gigantic new gas processing plant planned for Alberta. Owned by 25 companies, it will have the largest capacity of any gas plant in Canada. To be located near Rimbey, 50 miles south of Edmonton, the $12.5-million plant will process up to 326 MMcf of gas daily from the Dick Lake and adjacent Homeglen Rimbey fields. With combined recoverable reserves of 2.2 trillion cubic feet of pipeline gas, these two fields alone could supply Alberta's gas requirements for about 15 years at the present rate of consumption. British American Oil, in addition to operating the plant, will handle construction and maintenance. Survey crews are already at work on the site, and an access road is under construction. The general contractor, Poole-Pritchard Canadian, Ltd., is scheduled to have the plant in operation by November.

The plant will process up to 200 MMcf of raw gas per day from the Dick Lake field and 126 MMcf per day from the Homeglen Rimbey field. Based on this throughput, daily output of the Rimbey plant would include: 280 MMcf of saleable pipe line gas, 68,000 gallons of propane, 98,000 gallons of butane, 9,300 barrels of condensate and 233 long tons of sulfur. Approval for construction of the plant was granted January 20 by the Alberta Oil and Gas Conservation Board. The California Standard Co. and British American Oil together hold a 67 percent interest in the plant. Other owners include: Shell Oil Co. of Canada, Ltd.; Husky Oil & Refining, Ltd.; Phillips Petroleum Co.; Imperial Oil, Ltd.; Texaco Exploration Co.; Canadian Oil Companies, Ltd.; Western Decalta Petroleum, Ltd.; Calvan Consolidated Oil & Gas Co.; Pacific Petroleums, Ltd.; Union Oil and Gas Corp. of Louisiana; Tennessee Gas and Oil Co.; Western Leaseholds, Ltd.; Dome Petroleum, Ltd.; West Canadian Oil & Gas, Ltd.; Cree Oil of Canada (1958) Ltd.; Hudson's Bay Oil and Gas Co.; Medallion Petroleums, Ltd.; Amurex Oil Co.; Canpet Exploration, Ltd.; Murphy-Canada Oil Co.; Ashland Oil & Refining Co.; Canadian Superior Oil of Calif., Ltd.; and Great-West Life Assurance Co.

B. F. Goodrich Chemical Co. has named Scientific Design Co., Inc., to design and construct a polyvinyl chloride plant at Watson, Calif. The plant will employ Goodrich techniques and formulations when completed this spring.

Indonesia will build its first nitrogen fertilizer plant at Palembang, Southeastern Sumatra. Slated for completion in 1962, the new government plant will have an annual capacity of 100,000 tons of fertilizer-grade urea, and will have a design that will facilitate further expansion. The $30-million project will be built by Foster Wheeler Corp., and will employ the Pechiney-Grace total recycle process. Ammonia synthesis will be carried out by

where trouble-free performance is a matter of pride...

DOW CHEMICAL COMPANY, TEXAS DIVISION, FREEPORT, TEXAS

Heat exchanger tube

One of the largest of The Dow Chemical Company's manufacturing installations is the Texas Division, where, in complex and brilliantly-painted plants hundreds of different components are processed and re-shaped to produce more than 40 fundamental chemical products.

Chemical process condensers such as this at The Dow Plant, Freeport, Texas, are vital links in the production chain and are tubed with Cupro-Nickel, 30% Heat Exchanger Tubes.

Combining excellent corrosion-resistant properties with very favorable mechanical properties, Scovill Tubes of this alloy make an important contribution to the trouble-free operation of these key units under very exacting service conditions.

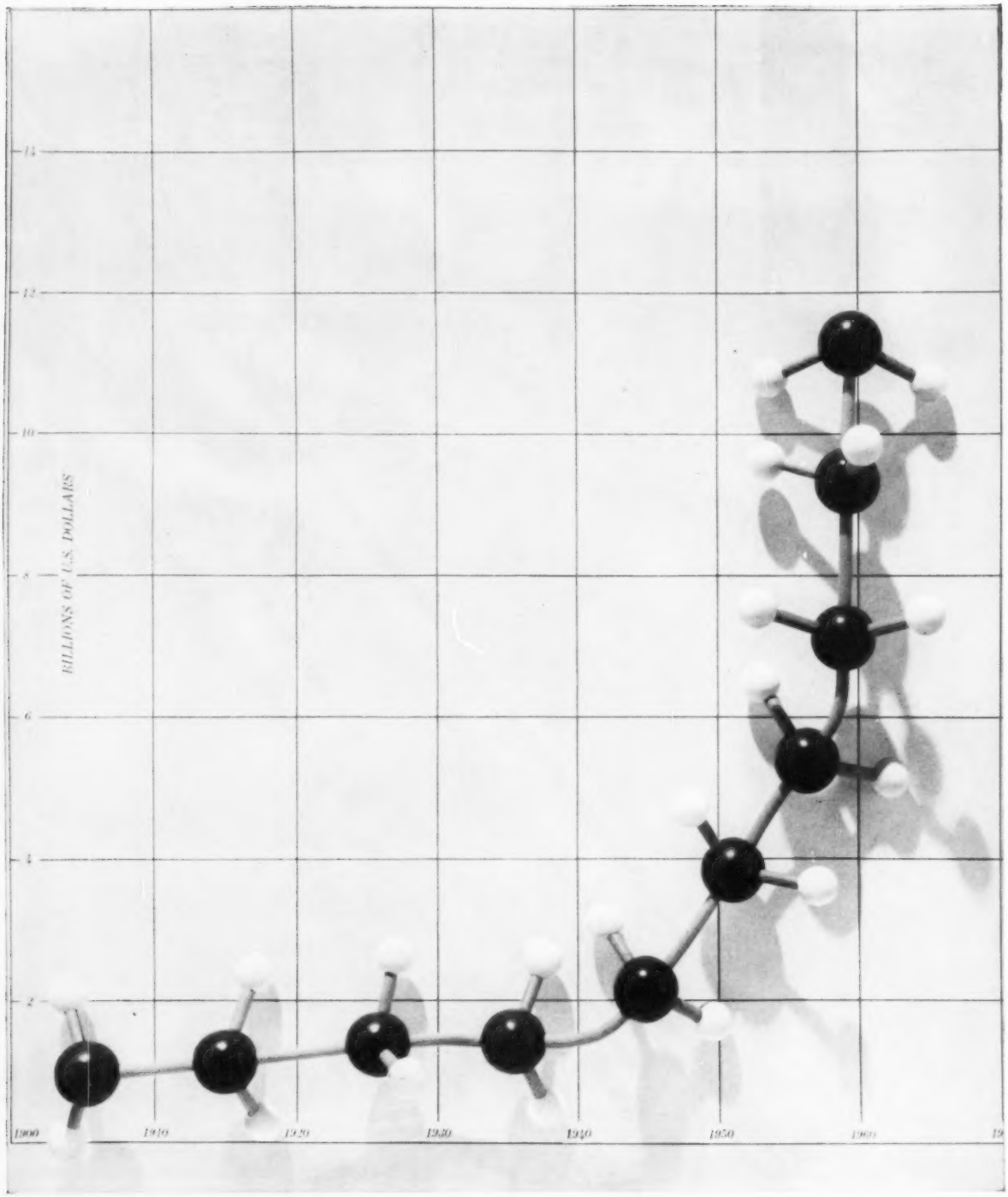
Let Scovill Technical Service . . . most experienced in the field . . . help you establish the best heat exchanger tube specifications for equally trouble-free service in your own heat transfer equipment.

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

HEAT EXCHANGER TUBE for Applications from Marine to Petrochemical, from Compressor Intercoolers to "Cat-Cracker" Exchangers, in these popular Alloys . . . Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Red Brass, 85% • Deoxidized Copper • Arsenical Copper • Cupro-Nickel, 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

SCOVILL MANUFACTURING COMPANY, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone PLaza 4-1171.

95C58R



"The upcurve in technology seems to be accelerating. In 1900, industrial research and development was practically non-existent. In 1928, the nation spent less than $100 million for these purposes. Today, expenditures for research and development exceed $10 billion . . . just about double the amount spent only six years ago." —M. J. Rathbone, President

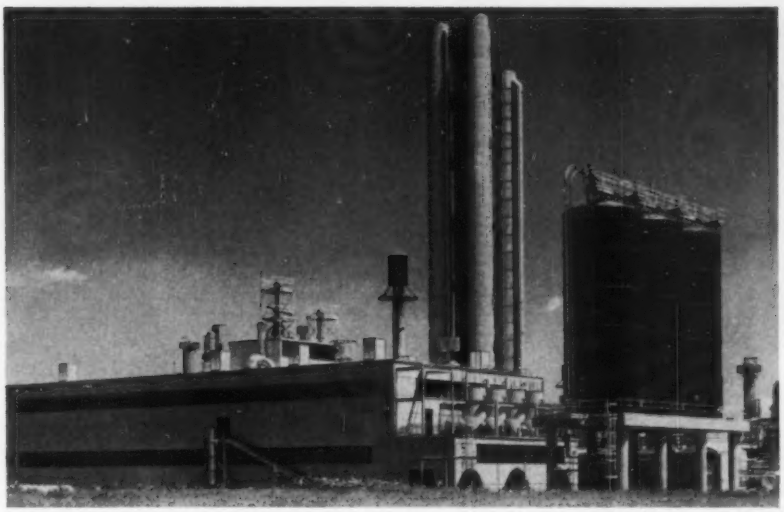
Standard Oil Company (New Jersey)

For more data on advertised products, use Readers' Service Cards, last page.

Building . . .

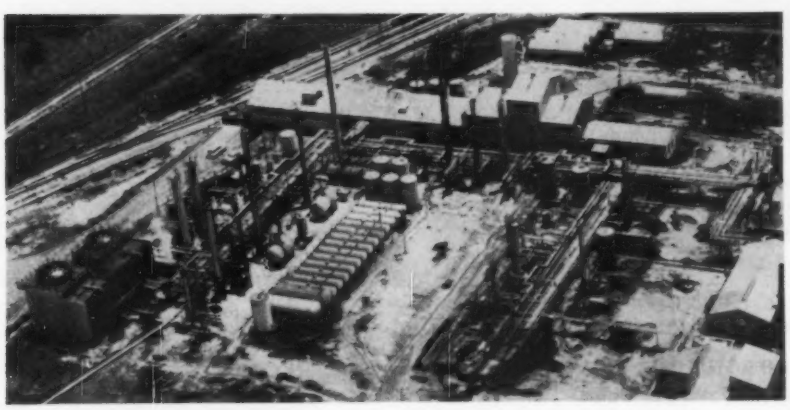
the Casale process based on the use of natural gas. The gas will be supplied by Standard Vacuum Oil Co. at the rate of 15 MMcf per day.

Continental Oil Co. plans to construct a $1-million cyclohexane plant at its Ponca City, Okla., refinery. Procon, Inc., will build the 20-million-gallon-per-year unit. Completion of construction is scheduled for September. Hydrogen from the refinery's catalytic reformers will convert benzene into cyclohexane.



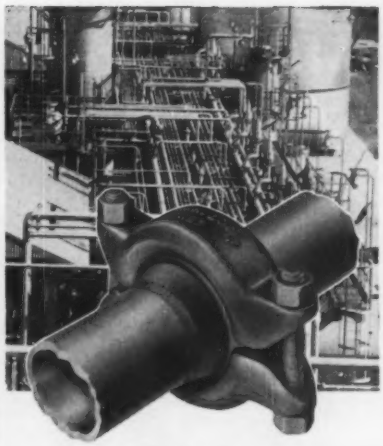
Cosden to Expand Texas Styrene Capacity

Cosden Petroleum Corp. plans to erect facilities at the pictured Big Spring, Texas, plant, to triple its styrene capacity. The multimillion-dollar project, including two major process units, will expand Cosden's styrene capacity to 60 million pounds annually when completed late this year. The contract for design, engineering and construction of the entire project, which includes additional facilities for styrene monomer production and this country's first Alkar Unit, has been awarded to Badger Manufacturing Co. The unit uses Universal Oil Product Co.'s process for ethylbenzene manufacture through catalytic alkylation of benzene with ethylene. Ethylbenzene is the precursor for styrene.



Jefferson Chemical Buys Conroe Plant

Jefferson Chemical Co. has acquired extensive chemical manufacturing facilities at Conroe, Texas. The plant, built in 1954, was purchased from Gulf Oil Corp. Jefferson Chemical will use the installation for intermediate-scale production of new products coming from its Austin, Texas, research laboratories and for larger scale development of new processes pilot-planted at Austin. Development of a new process for morpholine will also be undertaken at an early stage of the Conroe operation. Both batch and continuous processes will be operated,



GRAYLOC
New Principle of Pipe Connections

Two-bolt GRAYLOC Pipe Connections introduce a new principle in pipe make-up. Its design makes it possible for GRAYLOC to withstand full vacuum, high external pressure and extreme internal pressure. Moreover, this design makes it possible to make up GRAYLOC Connections repeatedly with no wear or other damage to the connections.

The bolting carries no primary force from internal pressures. Two bolts serve only to pull the connection together through the wedging action of the clamp and the seal ring.

Flexible tapered lips of the seal ring are angled slightly less than the mating hub. This forms a line seal which is changed to a surface seal as the connection comes together and the lips deflect.

GRAYLOC has practical uses in any application where flanges are used. GRAYLOC is recommended where pressures are high or where you want savings in money, space, weight or time.

For additional information, write, wire or telephone Gray Tool Company.

GRAY *Tool Company*

P. O. BOX 2291 HOUSTON, TEXAS
REpublic 4-1641 8903

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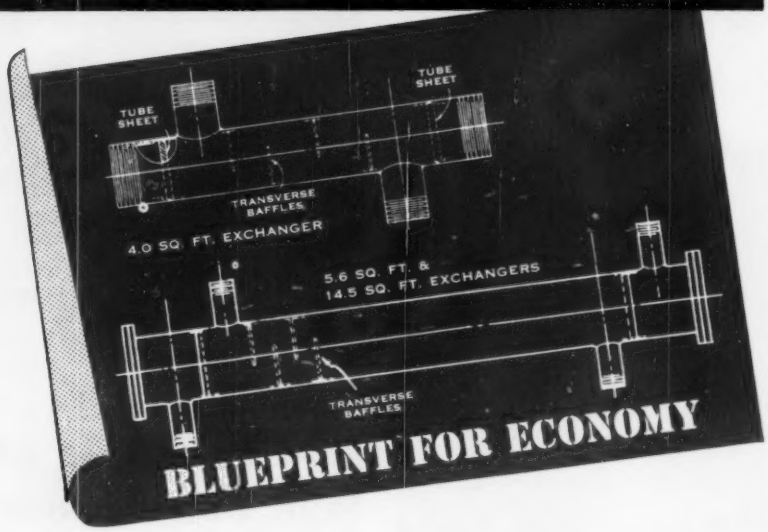
STANDARD Process HEAT EXCHANGERS



LOW COST . . . STAINLESS STEEL

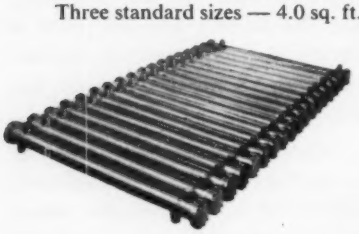
These small, compact exchangers are fabricated completely of Type 316 Stainless Steel which makes them ideally suited for corrosive chemical plant service and applications where product contamination by copper or copper-based alloys cannot be tolerated. Furthermore, there is no possibility of inter-circuit contamination since the tube–tube sheet joints are welded. These exchangers are applicable to all services — heating, cooling, evaporating, or condensing, and are well suited for commercial and laboratory use. Their light weight permits in-line installation without supporting cradles.

DESIGNED FOR SEVERE SERVICE

The straight tube–fixed tube sheet construction has proved highly successful. By merely removing the socket head studs in the covers at each end of the larger units, the tube circuit is accessible without disturbing any pipe connections. Particularly important is the combination of design pressure — 450 psig on the shell side and 300 psig on the tube side — and the welded tube-sheet joint which greatly reduce operating maintenance.

AVAILABLE FROM STOCK

Three standard sizes — 4.0 sq. ft. (furnished without channel covers for easy installation in pipe lines), 5.6 sq. ft. and 14.5 sq. ft. — are available for immediate shipment. Many users keep a stock on hand for their own requirements. Write for bulletin.



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CHEMICAL ENGINEERING CATALOG

THE WHITLOCK MANUFACTURING CO.
75 South Street · West Hartford 10, Conn.
In Canada: DARLING BROTHERS, LTD., MONTREAL

Whitlock

DESIGNERS AND BUILDERS OF BENDS, COILS, CONDENSERS, COOLERS, HEAT EXCHANGERS, HEATERS, PIPING, PRESSURE VESSELS, RECEIVERS, REBOILERS.

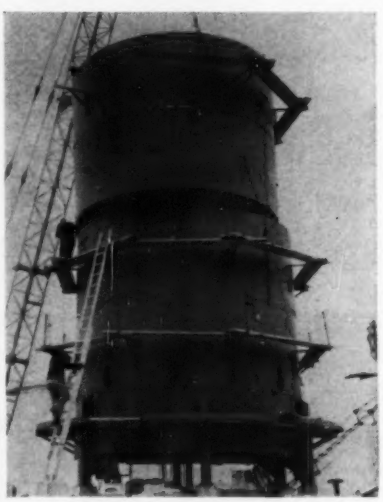
Building . . .

and it is expected that the plant will be on stream in mid-1960.

In addition to morpholine, intermediates developed for use in the polyurethane resin industry, and certain specialty surface-active agents, will soon be produced at the Conroe plant. Development of new processes will also be undertaken there. The acquisition is part of Jefferson Chemical's plans for expansion and new development in ethylene and propylene oxide derivatives. The plant consists of seven processing units (both continuous and batch), a process building containing equipment for handling both liquid and solids, hydrogen unit, control laboratory, shipping and receiving facilities, five boilers, two cooling towers, three wells, waste evaporation ponds, office building, and other general plant equipment. Approximately 50 percent of the process equipment is stainless steel.

Esso's Bayonne Pipe Still Is Nearing Completion

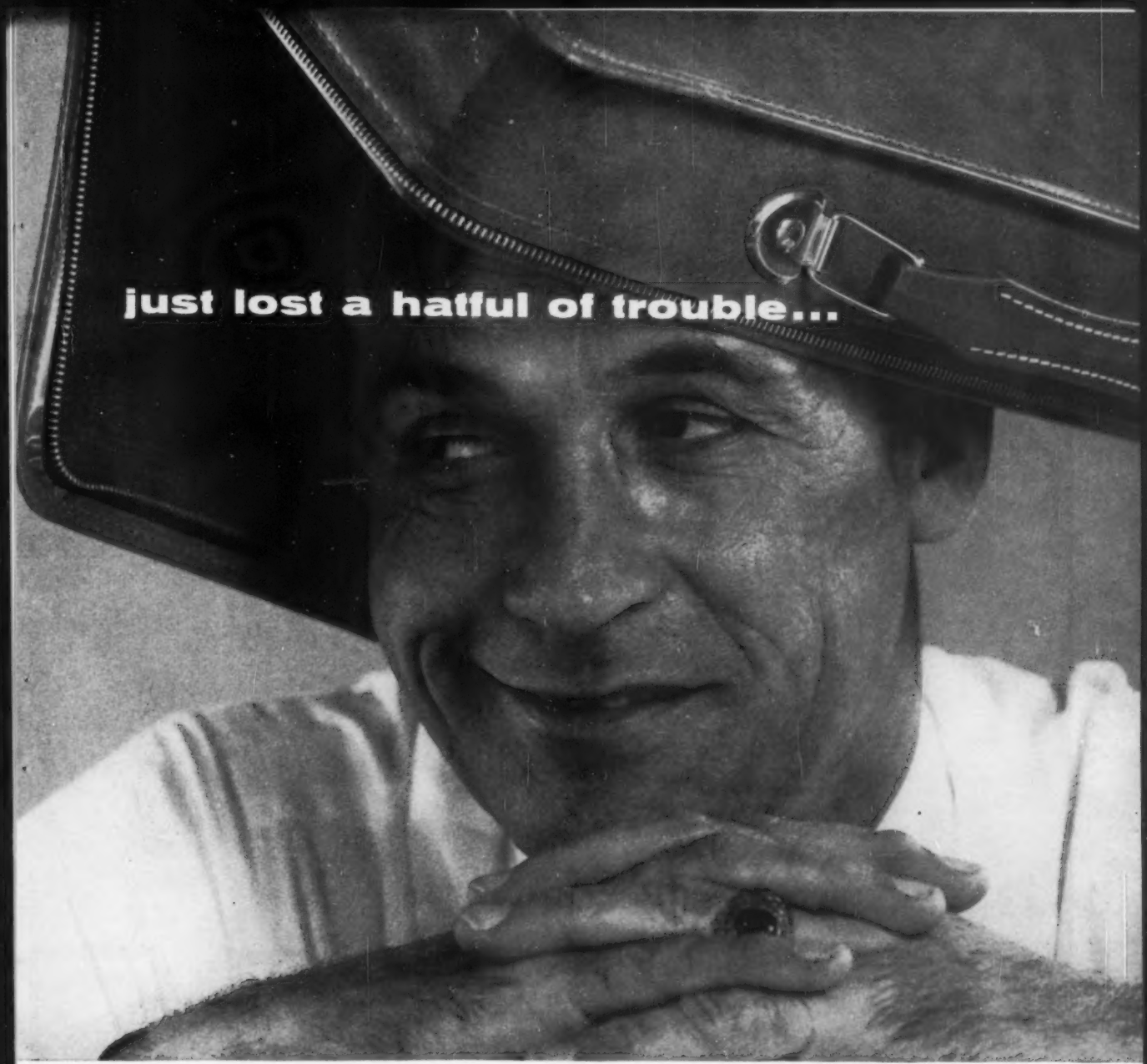
A new asphalt pipe still starts to take shape at Esso Standard Oil Co.'s Bayonne, N. J., refinery as workmen swing a furnace section into place. Completion



is scheduled by the end of this year. Asphalt production in the industry in 1959 was the highest on record, with the Bayonne refinery showing an eight percent increase. Forecasts for 1960 indicate a further industry increase of about five percent. Esso said the new pipe still at Bayonne will replace one which went on stream in 1929. The vacuum stage of the old still has been in operation since 1929, and the atmospheric stage was replaced in 1952.

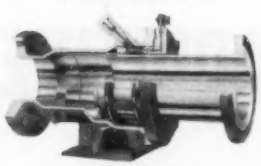
Fertilizantes de Centro America (Ferticas), a new company owned by International Development and Investment Corp. and Central American financial groups (50 percent each) plans to build a fertilizer plant in Central America. To be Central America's first such

For more data on advertised products, use Readers' Service Cards, last page.

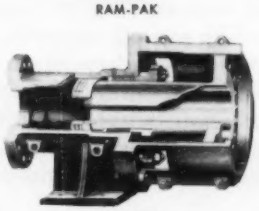


ONLY ADSCO HAS ALL 3 TYPES OF EXPANSION JOINTS

CORRUFLEX PACKLESS



RAM-PAK



SLIP TYPE

". . . to the Adsco man. He was here a minute ago . . . saw our piping problems in Area F and took them all with him. He'll bring 'em back solved next week and then I'll give him the order for the expansion joints."

Write for comprehensive catalogs

ADSCO DIVISION

World's Oldest and Largest Manufacturer of Packed and Packless Expansion Joints

20 Milburn St. Buffalo 12, N. Y.

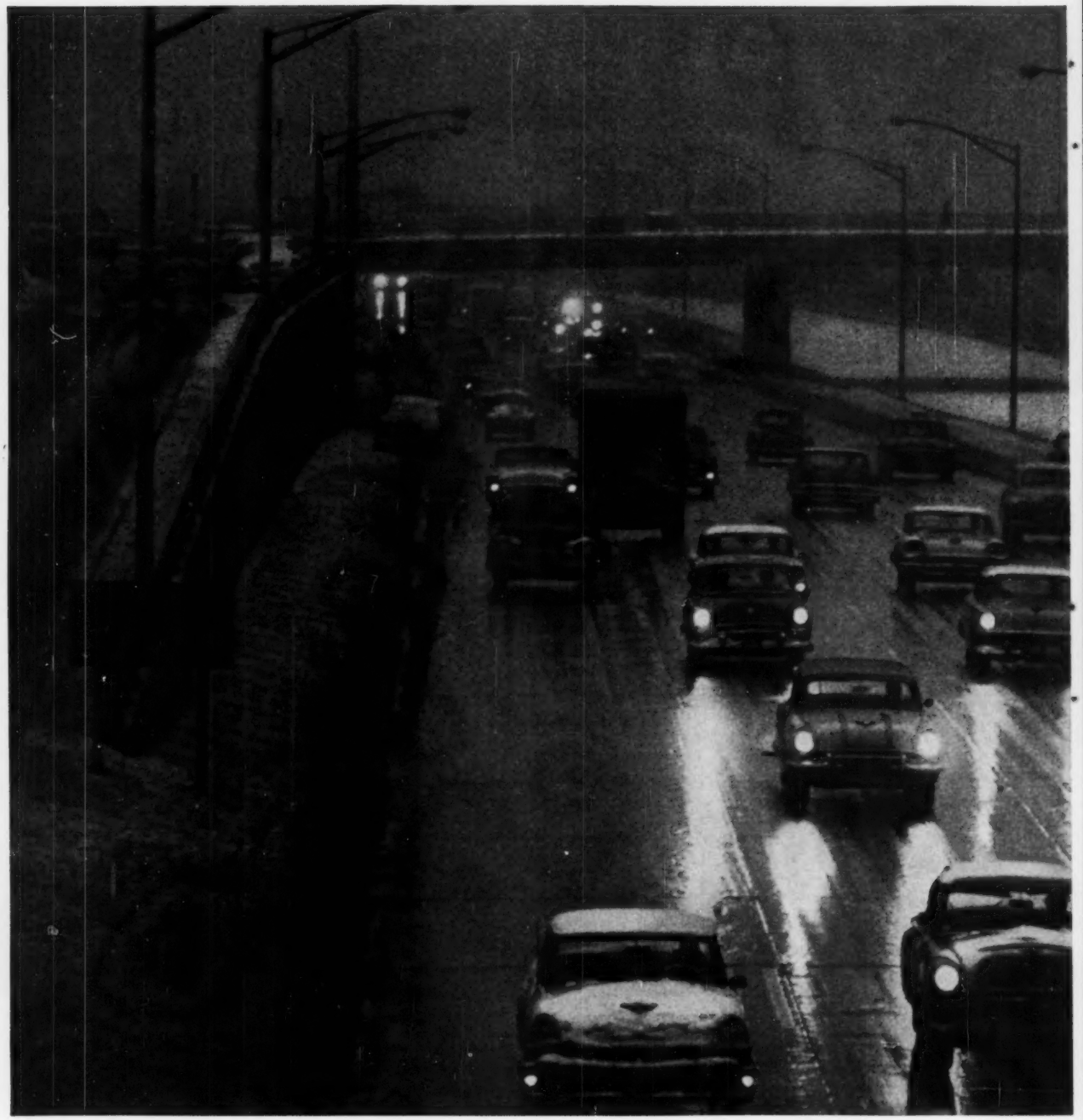
YUBA

YUBA CONSOLIDATED INDUSTRIES, INC.

Offices and representatives in principal cities

YUBA — A growth corporation serving growth industries

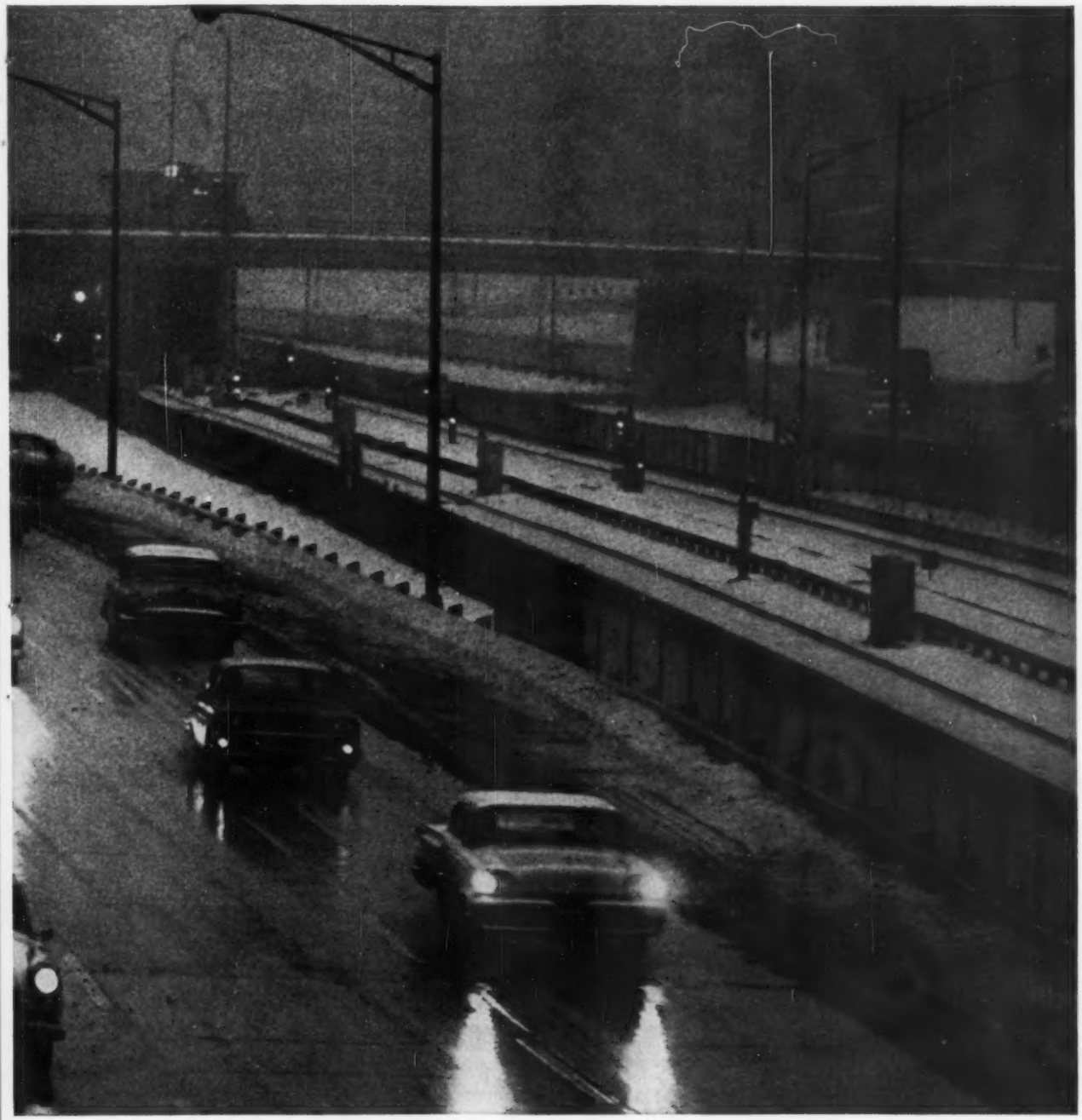
chemical
petroleum
steam — electric
hydro — electric
aeronautics
construction
heating
air-conditioning
consumer durable



ARMOUR ANTI-STALLING ADDITIVES

Armour's **Duomeen®** compounds have been used successfully by major oil refiners the past several years to prevent carburetor icing. These anti-stalling additives are so effective that they are used on a ppm basis . . . amounts so small your costs are reduced to a fraction of what you pay for protection gained by the use of freezing-point depressants.

In addition to their anti-stalling properties, Armour's additives also help prevent corrosion and keep air-borne contaminants from forming on carburetor walls and parts. To reconfirm their savings and effectiveness in operation, an independent laboratory runs continuing tests on these Armour additives. Test results consistently establish the superior prop-



KEEP 'EM ROLLING AT LESS COST

erties and economies of these Armour additives over freezing-point depressants.

Armour also makes a wide variety of chemicals as specialized additives for automotive uses. These polar nitrogen compounds have a broad range of use. In addition to preventing corrosion in greases, lube oils and gasolines, these compounds also improve lubricity in lubricating oils, transmission fluids and greases.

To learn more about Armour's gasoline anti-stalling additives and other refined product additives, and to receive samples of them, write to:

ARMOUR INDUSTRIAL CHEMICAL COMPANY
DIVISION OF ARMOUR AND COMPANY
110 North Wacker Drive, Chicago 6, Illinois

For more data on advertised products, use Readers' Service Cards, last page.

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FOR PLUS SERVICE

SERV-RITE drilled protecting wells are made in types, lengths, and of alloys to meet any temperature and pressure condition in vessels and flow lines.

Every well is carefully made to assure a plus service. Selected bar stock is machined to within accurate limits. Bore concentricity is held within 5% of wall thickness, depending on well length. They are tested to withstand pressures up to 3000 psi., depending on the wall thickness. Exterior surface has a mirror-like finish for minimum resistance to flow in lines.

Complete assemblies can also be furnished with suitable thermocouple, head, flange, fittings, etc.

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for specifications, size, and ordering information on SERV-RITE drilled wells.

8640

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Manufacturers • Engineers • Distributors

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Building . . .

plant, it will produce chemically combined nitrogen, potash and phosphorous fertilizer. The plant will be built in Costa Rica or El Salvador. The first stage will cost about $10 million and will have a capacity of 400 tons per day, plus 250 tons of ammonium nitrate. Future expansions will include acid or urea facilities. International Development plans to construct three additional fertilizer plants in Latin America.

Esso Standard Oil Co.'s Baton Rouge, La., refinery has started an expansion program to increase its annual production of butyl rubber by 38,000 long tons. According to the company, these modifications will provide increased operating efficiency and improved quality control, as well as additional capacity. The total capital cost of improvements currently in various stages of design and construction will be $16 million. Of the 38,000 long tons of new plant capacity at Baton Rouge, 20,000 will become available in mid-1960, followed by another 18,000 during the second quarter of 1961. This will increase total capacity at the Esso and Humble plants to more than 135,000 long tons per year. The company revealed that added butyl capacity will be provided as it is needed, and that further butyl plant expansions are under study at both Baton Rouge and Baytown.

United Carbon Co. plans to form a French subsidiary and build a $5-million carbon black plant near Rouen in North Central France. The new plant will be completed early in 1961 and will have an initial rated capacity of 50 million pounds per year. R. W. French, the company's president, said, "In choosing a plant location we consulted the French government, major users, and long-time customers of our Kosmos and Dixie reinforcing carbon blacks. Currently there is a concentration of rubber and end-product manufacturing facilities in Northern and Central France and further industry expansion in those areas is anticipated. Port Jerome, which is about ten miles north of Rouen, offers good raw material supplies . . . Current plans are to first produce the higher grades of reinforcing blacks such as FEF, HAF, ISAF, and SAF."

Shell Chemical (Australia) Pty. is planning to construct a $36.0-million catalytic cracking unit in New South Wales. To be erected at Shell's Clyde refinery, the new plant will produce high-octane gasoline. On completion, this unit will be the biggest of its kind in Australia and one of the biggest in the world, according to the company. It would have a capacity of 150 million gallons of gasoline yearly. When it comes on stream, Clyde's total gasoline output will be increased to more than 250 million gallons yearly—equivalent to a quarter of the total Australian consumption of the product. Greater flexibility to Shell's refining operations in Australia will be pro-

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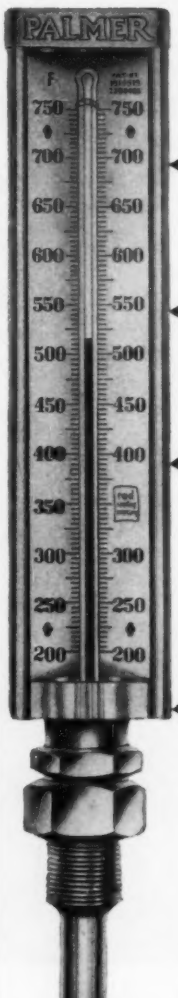

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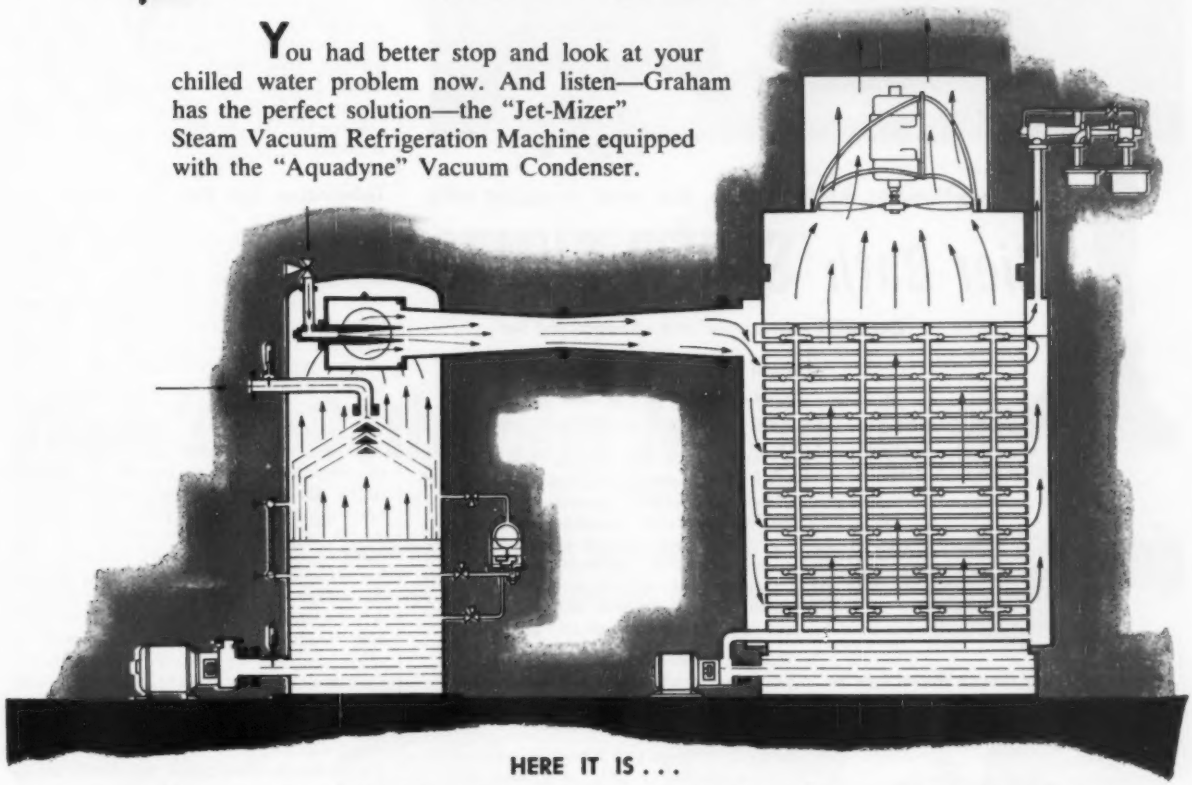
LOOK...
...and LISTEN!

Are you being held up for lack of cold water?

You had better stop and look at your chilled water problem now. And listen—Graham has the perfect solution—the "Jet-Mizer" Steam Vacuum Refrigeration Machine equipped with the "Aquadyne" Vacuum Condenser.



HERE IT IS . . .

. . . and here are a few of the things the "Jet-Mizer-Aquadyne" combination will do for you.

1. Provide any quantity of chilled water for your process requirements.
2. The Aquadyne Condenser requires no external source of cooling water whatsoever (provides its small amount of make-up water from its condensate).
3. A minimum of moving parts, hence a minimum of maintenance—completely automatic.
4. Extremely economical to operate and low in initial cost.

GRAHAM MANUFACTURING CO., INC.
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170 GREAT NECK ROAD • GREAT NECK, NEW YORK
Offices in principal cities and Canada

Factory: Batavia, N. Y. Other Graham precision-built products: Steam Jet Ejectors, Heliflow Heat Exchangers, Monobolt Heat Exchangers, Deaerating Heaters, Surface and Barometric Condensers.

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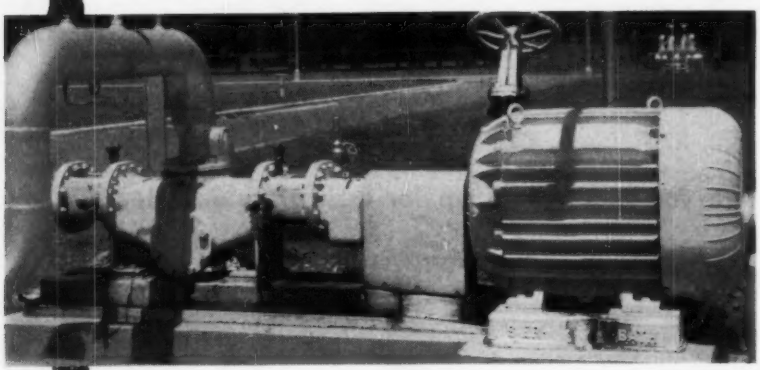


Get continuous, high-volume, low-cost pumping with

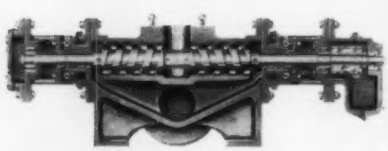
Sier-Bath SCREW PUMPS

Especially designed and constructed for

HIGH VISCOSITIES: 32 to 5,000,000 SSU
HIGH CAPACITIES: 1 to 2,500 gpm.
HIGH PRESSURE: to 1,000 psi.

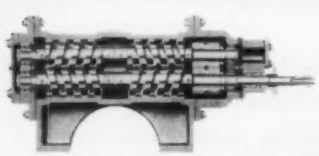
***Sier-Bath* SCREW PUMPS**

Sier-Bath Screw Pumps maintain high volumetric efficiency because "Dual-Controlled" precision rotor design prevents rotor-to-rotor or rotor-to-casing contact—provides a continuous flow without pulsation, hammering or vibration . . . without strains, misalignment and wear on rotors, shafts, bearings and gears.



External Gear and Bearing Bracket Type for non-lubricating liquids and semi-liquids

Result: Dependable, uninterrupted pumping service—less maintenance—easier servicing—longer pump life—lower overall pumping costs.



Internal Gear and Bearing Type for lubricating liquids and semi-liquids

Capacities from 1 to 2,000 gpm.; viscosities from 32 SSU to 1,000,000 SSU.; discharge to 1,000 psi. for viscous liquids, 200 psi. for water and light oils. Horizontal or vertical construction. Corrosion resistant alloys, special bodies, stuffing boxes and bearings for special needs. See "Yellow Pages" for your Sier-Bath representative or write Sier-Bath Gear & Pump Co., Inc., 9261 Hudson Blvd., North Bergen, N. J.

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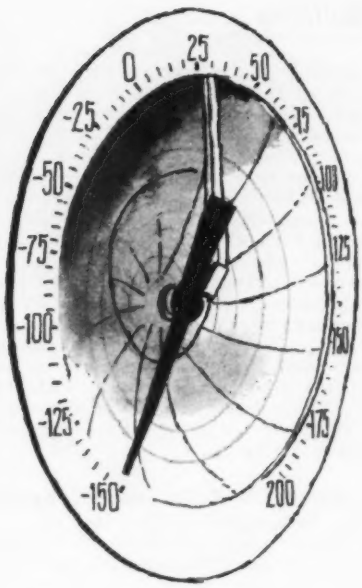
Founded 1905 **Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings** **Member A.G.M.A.**

Building . . .

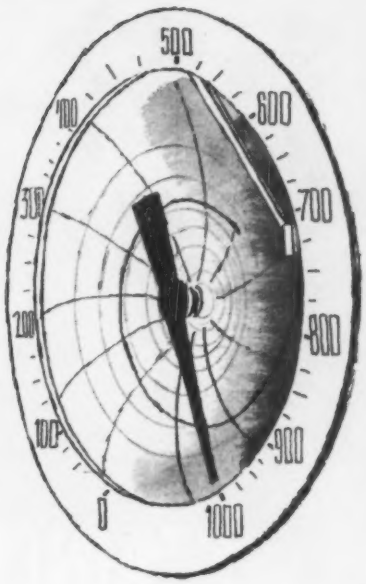
vided by the new plant, which will enable a wider variety of feedstock from different parts of the world to be used. The new unit will also provide a supplementary feedstock for the new ethylene manufacturing and purification unit jointly announced last December by Shell Chemical and Imperial Chemical Industries of Australia and New Zealand, Ltd. Work on the plant is expected to begin early this year, and it will take three years to complete. Associated with the project will be the construction of new port facilities at Gore Bay costing about $2.4 million. There will also be a pipe line for pumping oil from Gore Bay to Clyde, a distance of about 12 miles, and part of which will be under water. The pipe line alone is estimated to cost $1.92 million. Total investment at Clyde when these projects are completed will be about $90 million, bringing Shell's total investment in Australia to over $270 million.

Tidewater Oil Co. has started construction of a new cycling and sulfur recovery plant in the New Hope Smackover field, Franklin County, Texas. The unit is being built by Brown & Root, Inc. As the producer of 224 long tons of sulfur per day from 50 MMcf of raw gas, the new plant will be the largest of its type in Texas and the second largest in the country, according to the company. In addition to sulfur, the plant will be able to remove from the raw gas 7,500 barrels of distillate, 1,040 barrels of propane and 550 barrels of butane daily. Basic plant design employs conventional processes. Hydrogen sulfide, which is present in the raw gas in the amount of 15 percent by volume, will be removed by the Girbotol process and the sulfur recovered by the Claus process. After removing the sulfur and hydrocarbon products, the stripped gas will be reinjected into the Smackover Sand reservoir and held for future production and sale. Completion of the new plant is scheduled for early fall of 1960.

Sociedade Nacional de Refinacao de Petroleos, a subsidiary of the Portuguese company Sociedade Nacional de Petroleos, has awarded Procon (Great Britain) Ltd. a contract to build the first refinery for Mozambique, East Africa. Cost of the project has not been disclosed. Complete fuel oil, kerosine and gasoline production facilities will be built at Lourenco Marques, capital and major seaport of the East African country. Refining units will include a 12,000 bpd crude unit, a 2,500-bpd Platforming unit, 2,000-bpd diesel fuel Unifining unit, a 1,500-bpd Merox unit and supporting facilities. Completion of the refinery is expected in early 1961. Design of the crude unit is being done by Procon Inc., with purchasing, engineering and construction by Procon (Great Britain) Ltd. Design of the refinery is keyed to Mozambique's traditional role as a major refueling station and re-exporter of heavy fuel oils. Crude will be



Whatever the temperature



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Each meets ASTM Specification A-194.
Each comes in the full size range.

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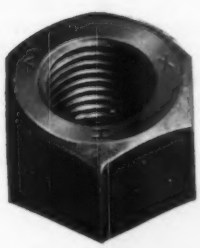
moderately high temperatures and pressures



GRADE 2H
higher temperatures and pressures

GRADE 4
severe temperatures and pressures

GRADE 4L
low temperatures

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

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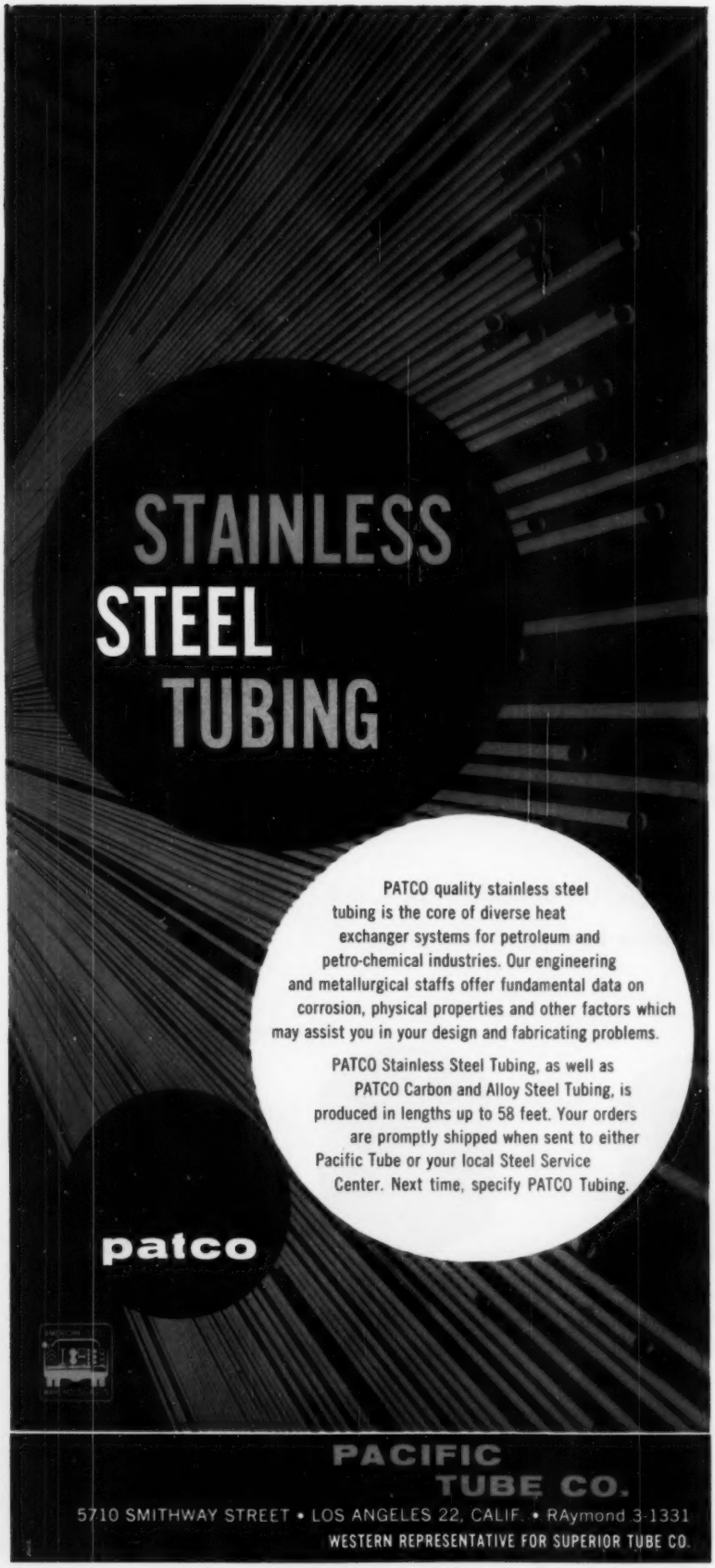
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Building . . .

supplied to the refinery from Middle East fields. Construction of its first refinery highlights the rising economy and increasing fuel consumption by Mozambique. Domestic use of petroleum products has risen steadily in recent years and currently is about 3,000 bpd. Consumption ratios are about 40 percent motor fuel, 40 percent heavy fuel oil, and 15 percent kerosine—with the remainder accounted for by lube oil and miscellaneous products. In addition to domestic consumption, large volumes of heavy oil have gone to Mozambique for refueling of ships and re-export to the United Kingdom, Portugal and the U.S.A. Currently, about 85 percent of all oil imports are from Aden, Iran and Saudi Arabia.

Sinclair Oil Corp. and Koppers Co., Inc., plan to build a large styrene monomer plant at Houston. A new jointly-owned corporation—Sinclair-Koppers Chemical Co., will be formed to own and operate the 70-million-pound-per-year plant. Construction is to begin immediately, and completion and initial operation is expected by the middle of 1961. Sinclair Refining Co. will supply raw material for the new company, and Koppers will use or market the plant's styrene output. The facility will separate ethylbenzene from an aromatic stream produced at Sinclair's Houston refinery. The ethylbenzene will then be converted to styrene monomer by dehydrogenation.

British American Oil Co.'s Calgary refinery has begun construction which will include revamping of the existing combination, crude topping, vacuum and thermal cracking units. The expansion program is scheduled for completion this fall and will increase the refinery's crude-running capacity from 7,500 to 10,000 bpd. A new control room will also be added and combine control instruments for the catalytic reformer, combination and treating units. Part of the expansion program already completed includes increased capacity for the reformer from 2,000 to 3,000 bpd and a 60,000 pound-per-hour steam generator.

Tidewater Oil Co. has begun construction of a modern 100,000-barrel bulk-petroleum marine terminal in South Norfolk, Va. The new $500,000 terminal will be built on a 60-acre site at Money Point, on the southern branch of the Elizabeth River. The terminal is scheduled to be completed in the fall and will include four product storage tanks, pier loading racks, warehouse and office facilities. While the 100,000-barrel capacity is expected to be adequate for the present, the size of the site allows expansion to one million barrels.

The Dow Chemical Co. plans to up capacity of its Freeport, Texas, polyethylene plant by 67 percent. Engineering is under way and completion of the new

For more data on advertised products, use Readers' Service Cards, last page.

Installed on caustic lines in 1930, these Rockwell-Nordstrom lubricated plug valves needed only cleaning before installation in new plant.

THE VALVES THAT WOULDN'T RETIRE

The Rockwell-Nordstrom lubricated plug valves shown above were two of dozens installed in 1930 on caustic lines at a process plant. When the plant was torn down in 1959, the valves were still in such good condition that they're being used on the same service in the new plant.

The above story is just one more example of the ruggedness of Rockwell-Nordstrom valves. Since they're sealed positively against leakage by pressurized lubricant and there are no exposed metal-to-metal seats, you get positive shut-off year after year. And, lubrication is preventive maintenance against the high cost of repairs, replacement and downtime. To get complete details on Rockwell-Nordstrom, the original and world's most complete line of lubricated plug valves, lubricants and accessories, write: *Rockwell Manufacturing Company, Pittsburgh 8, Pa.; Canadian Valve Licensee: Peacock Brothers Limited, Montreal, Quebec; Rockwell International S.A., Geneva, Switzerland.*

Lubrication Makes The Difference

ROCKWELL-Nordstrom VALVES

another fine product by

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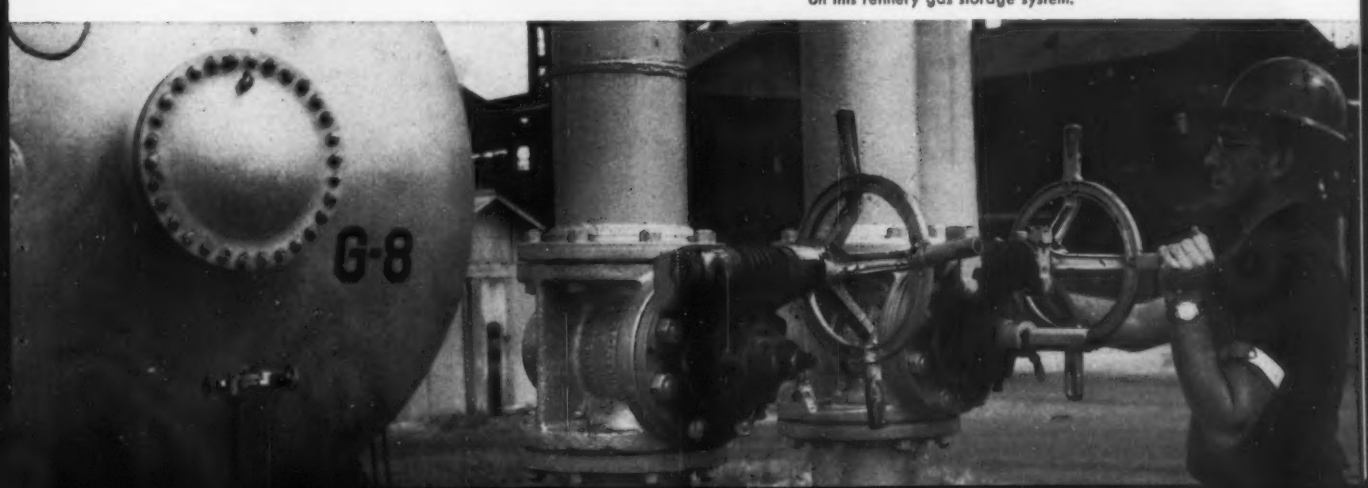
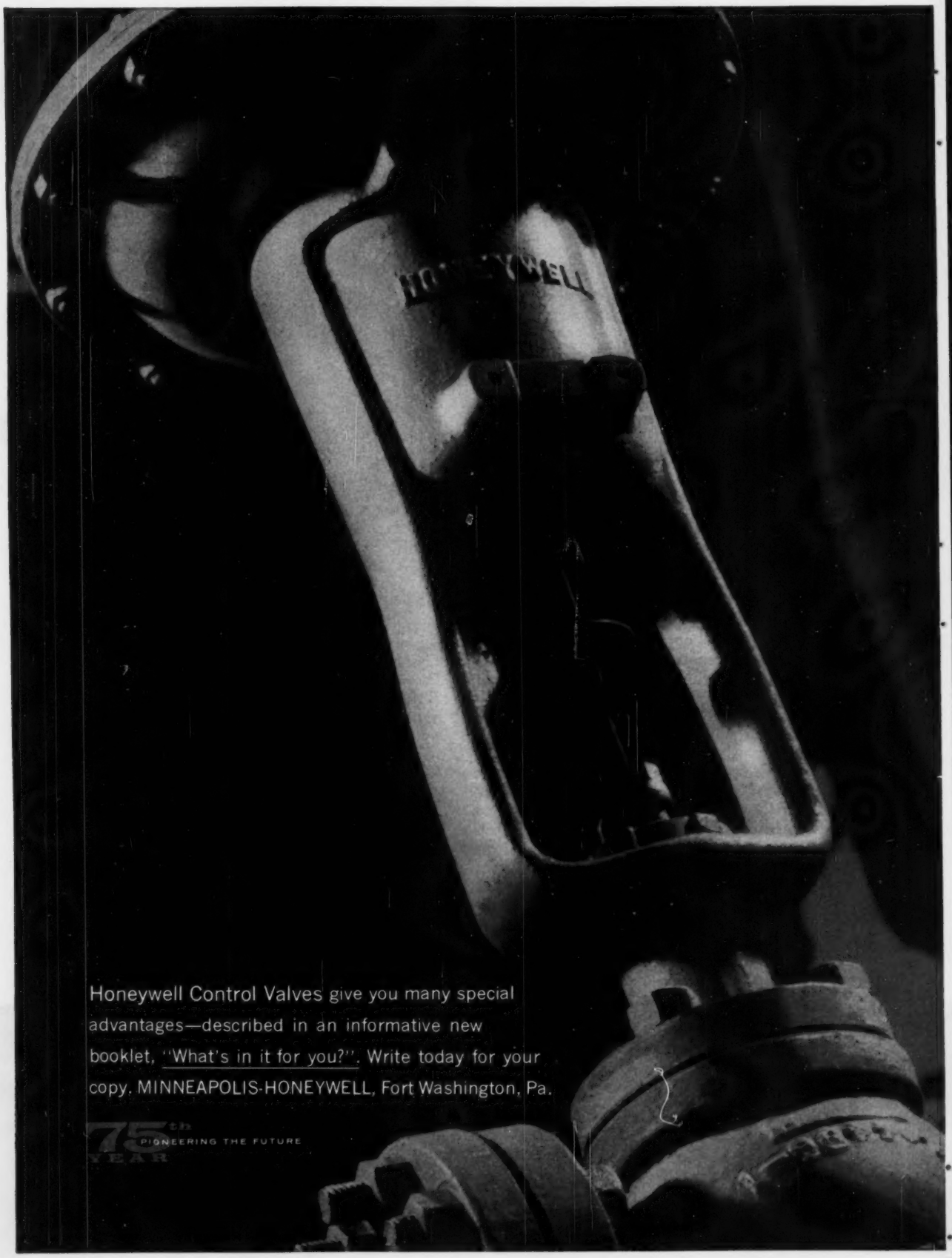
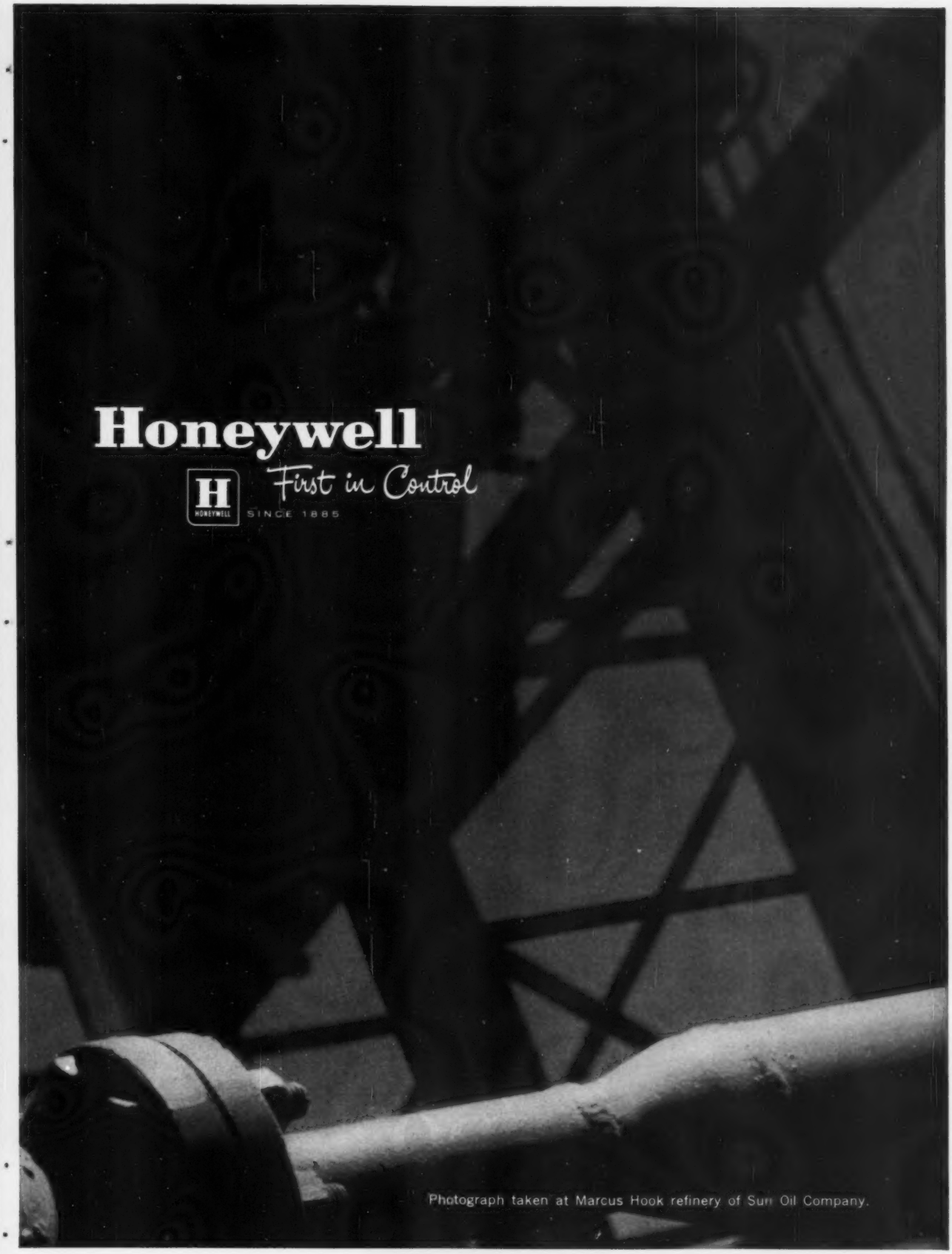


These gear operated Rockwell-Nordstrom valves have given many years of trouble-free service, positive shut-off on this refinery gas storage system.


Honeywell Control Valves give you many special advantages—described in an informative new booklet, "What's in it for you?". Write today for your copy. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.
75th YEAR
PIONEERING THE FUTURE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Photograph taken at Marcus Hook refinery of Sun Oil Company.

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The Finest of all Power Drives
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For performance, dependability and quality, this rugged little workhorse can't be equaled. Its new Spin Torque Chuck virtually eliminates the chance of chips falling into moving parts . . . heavy-duty sealed gear train is factory-lubricated . . . powerful TOLEDO motor with rugged switch draws only 13 to 14 amps at full load . . . new centering device for instant, accurate centering . . . heavy-gauge steel base with center screw for bench or stand mounting in any position through 360° . . . many other outstanding TOLEDO features. Accessories include a lightweight folding stand with cast top and sturdy folding steel tray. Write for free literature today and see this new 58 at your supplier's soon.

Sealed Gear Train with precision hobbed helical gears is factory-lubricated—complete unit easily removed.

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BUILDERS OF THE WORLD'S FINEST PIPE TOOLS

THE TOLEDO PIPE THREADING MACHINE COMPANY TOLEDO 4, OHIO, U.S.A.

Building . . .

facilities is expected in 1961. The multimillion-dollar expansion program will increase Dow's annual polyethylene capacity to about 165 million pounds a year. Dow, in May 1959, announced the doubling of its polyethylene capacity for the second time in a year following completion of a new plant at Freeport. Two other polyethylene facilities—at Dow's Louisiana Division, Plaquemine, and Saginaw Bay Division, Bay City, Mich.—are expected to be in production this year.

Goodrich-Gulf Chemicals, Inc., has begun advanced engineering work leading to commercial production of two new synthetic rubbers, based respectively on polyisoprene and cis-poly-butadiene. The company plans to produce both of these rubbers interchangeably in the same commercial plant facility. Planned is an initial commercial plant with an annual capacity of about 25,000 tons, to be in operation by late 1961. Sites under consideration include locations in Orange County, Texas, and Institute, W. Va.

The Standard Oil Co. (Ohio) has completed a $140,000 addition to its Cleveland Research Center. This new building contains a high-bay laboratory suitable for pilot-plant operations. There will be a 170 percent increase of pilot-plant facilities at the Research Center. The building contains a large air-conditioned laboratory of standard height, and three offices. New pilot plants are being set up and will be operated by personnel of Sohio Chemical Co., the company's petrochemical subsidiary.

B. F. Goodrich Chemical Co. plans to build a new plant for vinyl resins and compounds at Long Beach, Calif. Construction work on the installation is already underway and completion is slated for the second quarter of 1960. It is the first B. F. Goodrich plant west of the Mississippi River. Vinyl monomer feedstock will be obtained from American Chemical Co.'s nearby petrochemical operation.

Standard Oil Co. of Calif. has begun construction of a multimillion-dollar plant to manufacture chemical maleic anhydride at its Richmond, Calif., refinery. The 20-million-pound-per-year installation is being built by Badger Manufacturing Co. for Oronite Chemical Co., a Standard subsidiary. Completion is scheduled for mid-1960. The new plant is the first such installation in the Western U.S., according to the company.

Dow Chemical International, Ltd., S. A., plans to construct a styrene-butadiene latex plant in Rotterdam, The Netherlands. It will be built and operated by Dow's wholly-owned Dutch subsidiary, Nederlandsche Dow Maatschappij N.V., at the site of its present terminal and warehousing facilities in the Third Petroleum Harbor, Rotterdam. Investment

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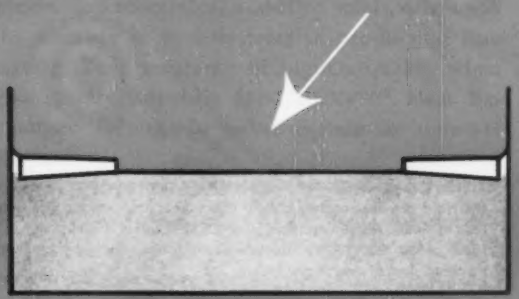
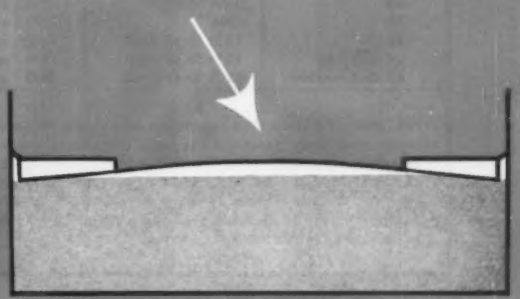
a "built-in" feature of HORTON® FLOATING ROOFS for over 35 years



The Horton Pontoon Floating Roof has an annular pontoon around the outer edge of the roof and a deck of single thickness at the center. The pontoon provides effective air space insulation for a large area of the liquid surface. Under normal conditions, the underside of the Horton Pontoon Floating Roof is in contact with the product in the tank.



Increased temperatures may cause the product in the tank to boil. Should this occur, the vapors are trapped beneath the center section of the roof due to the upward slope of the pontoon bottom and the flexibility of the center deck. The trapped vapors lift the center of the deck and provide an insulating vapor space to reduce further boiling.

130,000-bbl. tank equipped with a Horton Pontoon Floating Roof serves the marine loading terminal of a West Coast oil company.

Prime reason for equipping flat-bottom storage tanks with floating roofs is to prevent the loss of valuable volatiles through evaporation. Efficient vapor trapping is essential for the more volatile stocks.

The sun's rays striking the single deck portion of a floating roof heats the deck and the product beneath. Boiling often occurs, causing vaporization. Unless these vapors are retained by the deck rising from the product, boiling will continue. Horton Pontoon Floating Roofs trap these vapors. They form an insulating space during the heat of the day retarding further boiling. As cooler temperatures occur, the vapors recondense and the deck returns to the liquid surface. The result: *Maximum protection against costly evaporation loss and deterioration of product.*

Vapor trapping is just one of the many money-saving features that have made Horton Floating Roofs your best buy for over 35 years. Write today for the complete story.

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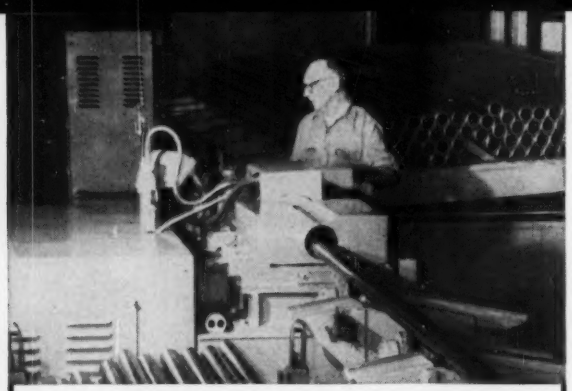

FARROWTEST REJECT TABLE

Wall Thickness (B.W. Gage)	Minor dimension of the defect (Length or Depth)	Defective Area (Length, Depth Plane)
20	.006″	.0025 sq. inches
18	.006″	.003 sq. inches
16	12½% of wall	.003 sq. inches
14 and 13	12½% of wall	.004 sq. inches
12 and heavier	12½% of wall	.005 sq. inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.

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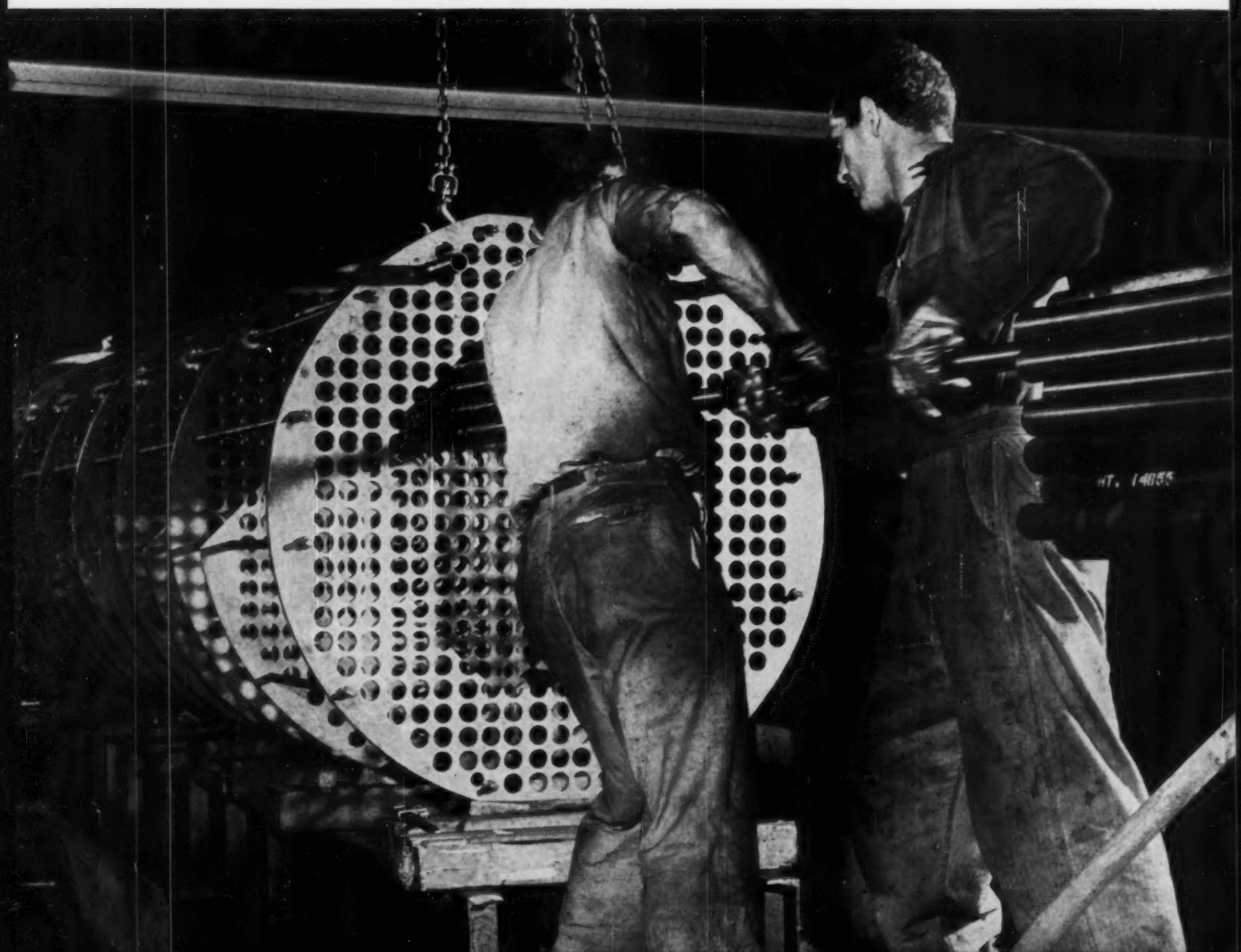
FARROWTESTED ELECTRUNITE

REPUBLIC ELECTRUNITE STAINLESS STEEL HEAT EXCHANGER TUBING meets the rigid requirements of critical processing and refining operations. It rolls in easily, resists corrosion, protects the quality of the product. Specify Republic ELECTRUNITE Stainless Steel Tubing for your original and retubing operations. Write today.



Heat exchanger tubing . . . carbon and stainless steels

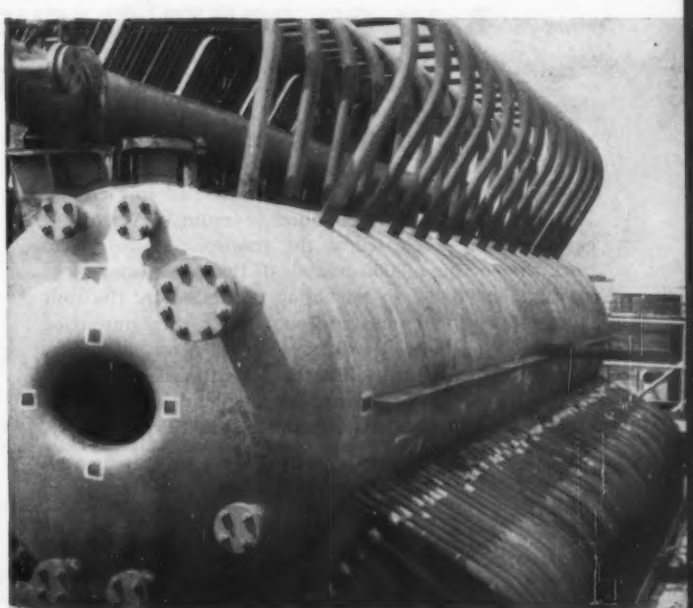
FARROWTEST®—exclusive with Republic. Most experienced tube maker and world's leader in the production of stainless and alloy steels, offers you the ultimate in non-destructive production line testing. Your assurance of highest quality when you specify Republic ELECTRUNITE® Heat Exchanger Tubing—in either carbon or stainless steels.

FARROWTEST looks deep within the tube wall electronically, is calibrated to reject minute defects as shown in the table, left. Injurious defects larger than those shown in table may pass ordinary pressure tests. But, they cannot pass FARROWTEST.

FARROWTEST is offered as an alternative to other less positive tests at no increase in cost. Carbon Heat Exchanger Tubes produced to ASTM specification A-214; Stainless Heat Exchanger Tubes to A-249. Both specifications include eddy-current requirements—FARROWTEST.

Get quality produced, quality protected heat exchanger tubing on your next order. Specify Republic ELECTRUNITE—exclusively FARROWTESTED for your protection. For first-hand facts, call your Republic representative. Or, write direct.

PROTECT YOUR PRODUCT WITH REPUBLIC STEEL CONTAINERS. Republic's full line of steel containers helps you extend control of product from your shipping floor to the point of use. For complete information, call your Republic representative. Or, write for the Republic Containers Catalog.



REPUBLIC STEEL

DEPT. PR-8835 • 1441 REPUBLIC BUILDING

CLEVELAND 1, OHIO

REPUBLIC ALLOY STUDS AND HIGH CARBON HEX NUTS solve many problems in the processing industries. They withstand major stress imposed on a wide variety of equipment. Clean accurate threads provide high strength and wear resistance with maximum holding power. Write for latest information.

Manufactured and installed by Babcock-Wilcox & Goldie McCulloch, Limited, this B&W CO Boiler uses 222,400 lb/hr catalytic gases at 600 F. These gases contain 4.6 per cent CO (by volume) plus traces of entrained hydro-carbons.

B&W CO BOILER SLASHES STEAM GENERATING FUEL COSTS FOR BRITISH AMERICAN OIL

At the Montreal East Refinery of the British American Oil Company, a B&W CO Boiler installed in October, 1957, has proved to be a sound investment. Waste CO gases, normally released to the atmosphere, are put to work to generate 60,000 pounds of steam per hour. Add to this the 90,000 lb per hour generated by the unit from conventional fuels and you have a total output of 150,000 lb per hour. No wonder British American points to this unit with pride. It saves them thousands of dollars yearly in fuel costs; furnishes a dependable supply of high quality steam that helps over-all refinery efficiency.

Similar Savings for your Refinery. By recovering sensible heat and the heat of combustibles in the waste gases, a B&W CO Boiler can mean similar savings for your refinery. In addition, B&W CO Boilers give your community relations a big assist by removing entrained hydro-carbons from waste gases—thereby helping to lick the troublesome problem of air pollution.

Find out how a B&W CO Boiler can Help you Cut Costs. These are practical advantages that can help improve your refinery operations. There are many more that add up to increased efficiency and economy. Get the complete story by writing for Bulletin G-87, The Babcock & Wilcox Company, Barberton, Ohio.

CO-101

B&W

THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

Building . . .

in the new plant will total more than $2 million. Completion of the plant is scheduled for early spring of 1961. It will supply latex to manufacturers of industrial paints and packaging materials and to textile and paper industries.

Suntide Refining Co.'s newly completed $2-million delayed coking unit at Corpus Christi, Texas, announced in the February PETROLEUM REFINER, page 182, incorporates a new control system. The system transmits process information from various points in the unit to the control room at the speed of light. The coking unit at Corpus Christi is the first to be completely equipped with the new electronic system, according to the company. The system requires only two unshielded wires to carry its 4-20 milliampere, DC signal to any of the transistorized transmitters within the unit. The new coking unit has a capacity of 7,000 bpd and will produce a high-quality petroleum coke, propane-propylene, butane-butylene, gasoline and gas-oil.

Utah Oil Refining Co. plans to spend more than $21 million during the next five years to expand manufacturing and marketing. This year, the Manufacturing Division will spend $1.5 million for facilities. Improvements planned for the firm's Salt Lake City, Utah, refinery will include expansion of the catalytic cracker and alkylation unit. These installations make components for aviation and premium-grade gasoline. Increased tankage units and waste-water treatment facilities will be improved.

Monsanto Chemical Co. has begun operations of what it says is the first computer-controlled chemical plant in the United States, at Luling, La. The ammonia plant is well into its testing period and performance is up to expectations, says the company. The direct, on-line computer continually monitors process conditions and adjusts controls for optimum results. The unit was installed by Thompson-Ramo-Wooldridge, Inc.

Cosden Petroleum Corp. is planning an expansion of ortho-xylene facilities—to be completed early in 1961 at Big Spring, Texas. Production will exceed 70 million pounds per year, and design will permit capacity to be doubled. Since April 1958, Cosden has been the world's only supplier of 99 percent ortho-xylene in commercial quantities. The petrochemical is used in synthetic resins, pharmaceuticals, and dye-stuffs.

The Dow Chemical Co. has selected Kalama, Washington, as the site for a 36-million-pound-per-year phenol plant. Test drilling has been completed at the 150-acre site on the Columbia River, about 30 miles north of Vancouver, Wash. Land-fill operations have begun, and completion of construction is expected in mid-1961. Plans for the new plant have been in the mill for several

PIN

POINT

YOUR

GAS

TRANSPORTATION

WITH

TAYLOR-WHARTON

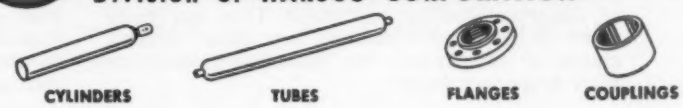
MOBILE

GAS STORAGE

More than a Century in Harrisburg 2, Pa.

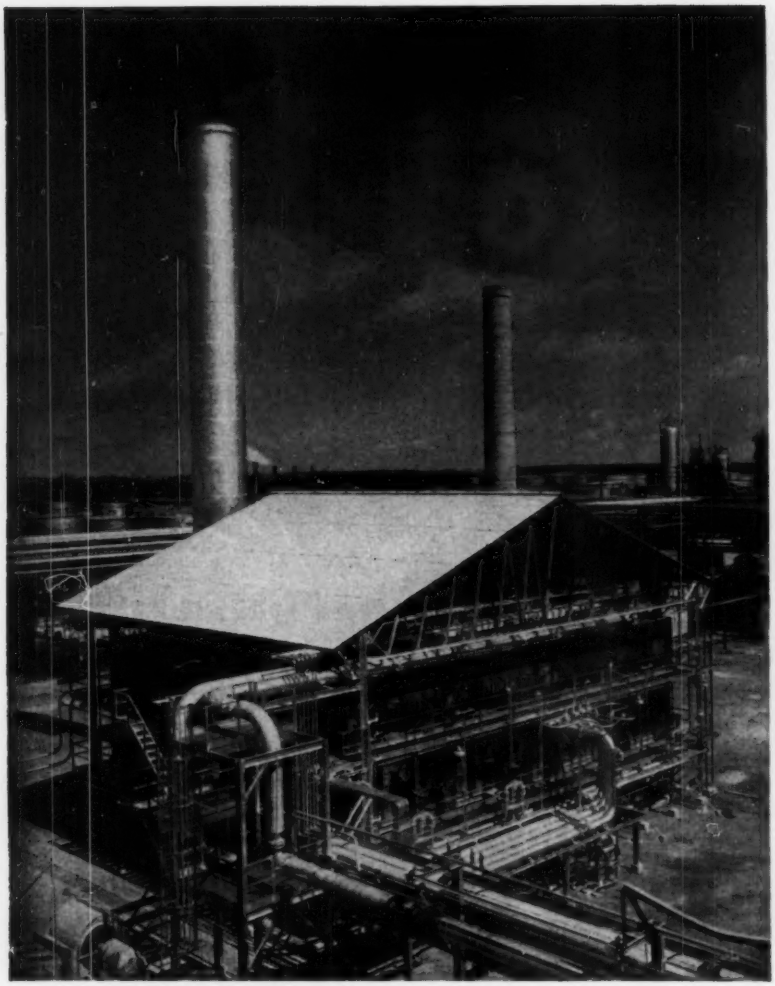
H HARRISBURG STEEL CO.

Division of HARSCO CORPORATION



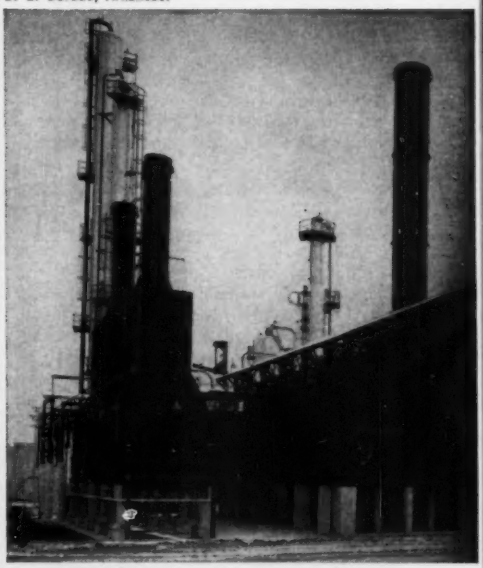
CYLINDERS TUBES FLANGES COUPLINGS

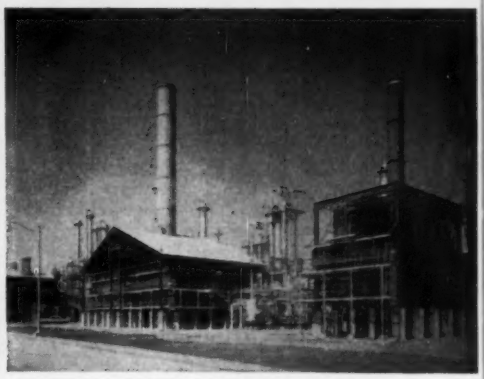
For more data on advertised products, use Readers' Service Cards, last page.



Portable crude heater for Magnolia Petroleum Company, Beaumont, Texas.

Ultraformer heater for American Oil Co. at El Dorado, Arkansas.





Platformer and desulphurizer heaters for Shell Oil Co. at Deer Park, Houston, Texas.

HIGHER EFFICIENCY, LUMMUS OIL HEATERS

Lummus designs horizontal and vertical-tube oil heaters to any size, for any process—anywhere in the world

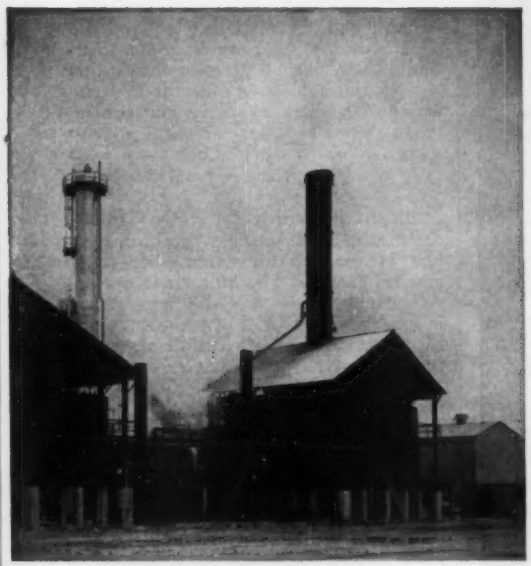
Major refiners confidently turn to Lummus on their important and difficult oil heater jobs.

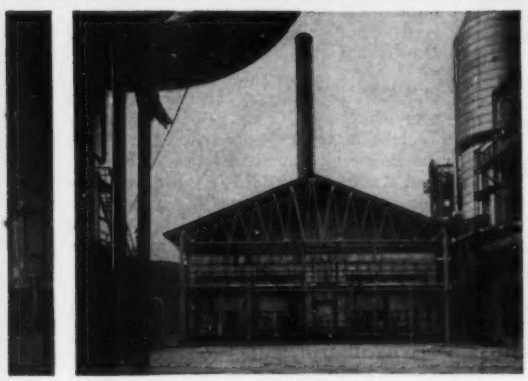
In the last 25 years, the combined capacity of all Lummus oil heaters built has exceeded that of any other company in the world. The reasons: greater durability, more efficient operation, an absolute minimum of days lost to downtime.

Major refiners maintain large engineering and economics staffs who can evaluate the performance of important heating equipment. They buy more Lummus oil heaters because they *know* through statistical comparison that Lummus gives them *more heater per dollar.*

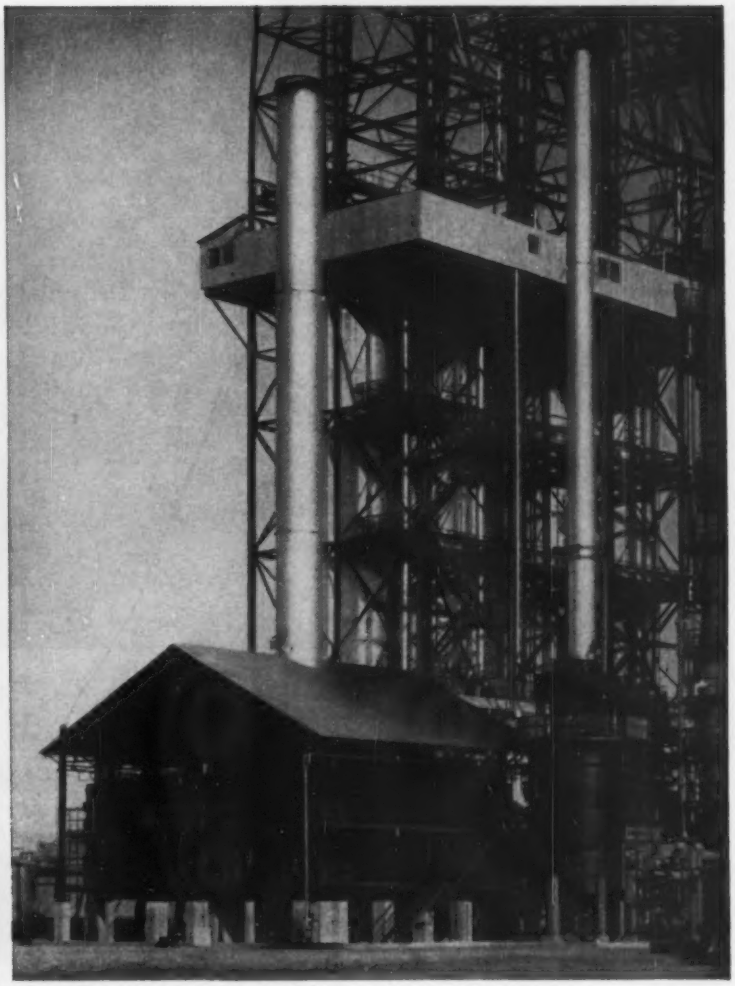
Lummus offers over a quarter of a century of oil heater experience for petroleum refineries, chemical and petrochemical plants. The highly trained engineering staff of the Oil Heater Division is ready in the Lummus New York office to give each job the full benefit of its accumulated know-how in this field.

Lummus oil heaters, of both special and standard design, range from 100,000 to 300,000,000 Btu per hour. As illustrated above, neither size, type nor location of the unit presents a problem to Lummus. Because Lummus offers *every* type of oil heater, you can be sure that we will recommend the *right*





Crude heater for Socony Mobil at Paulsboro, N. J.



Delayed coker heater for the American Oil Co. at Yorktown, Virginia.

MINIMUM DOWNTIME MAKE PREFERRED AMONG MAJOR REFINERS

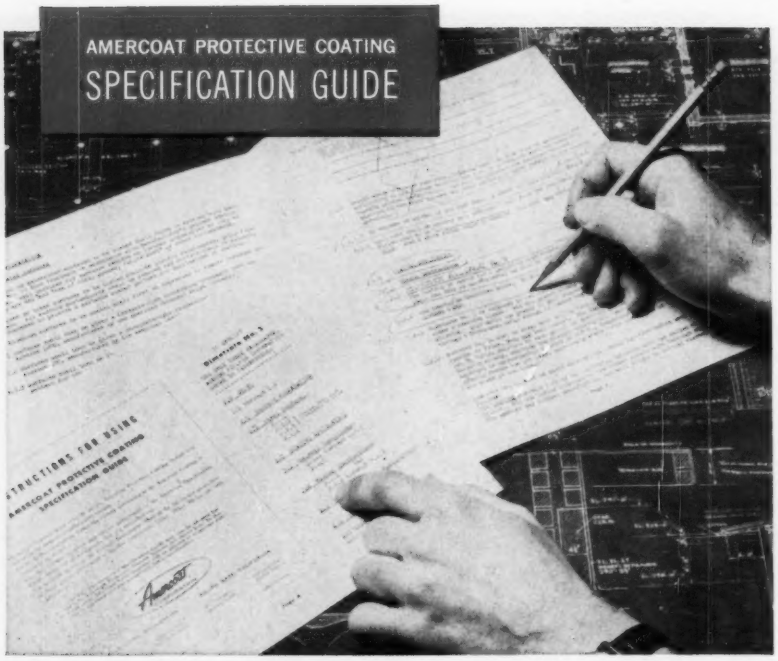
unit for your needs. Complete Lummus facilities are available world-wide through any of the five international Lummus companies. Equipment is designed in New York, procurement is made through the nearest Lummus international office, and the cost of the job is payable in the currency of the country in which the procurement is handled!

Consult with Lummus on your next oil heater – large or small.

LUMMUS

THE LUMMUS COMPANY, OIL HEATER DIVISION
385 MADISON AVENUE, NEW YORK 17, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.



Here's the Beginning of a Good Coating Job

Tight, comprehensive specifications are the beginning of a successful protective coating application. Unless specifications are complete and detailed, costly failures or confused, inaccurate bidding can result.

Now, engineers who write specifications for protective coating applications can insure complete, accurate specifications through use of the new Amercoat Protective Coating Specification Guide.

The Guide is based on recognized best practices in the industry, such as Steel Structures Painting Council Specifications, and contains paragraphs covering all phases of coating application from surface preparation to inspection.

In use, appropriate paragraphs in the Guide are selected according to the coating to be used and the condition involved. At this step, your Amercoat Sales Engineer will be pleased to cooperate with you in deciding upon the most effective coating or coating system for the job requirements. The finished specifications can then be copied by a typist.

Use of the Amercoat Specification Guide assures tight specifications that spell out every step necessary to eliminate confusion when the contractor bids and to insure a satisfactory application later. Job delays and extras are reduced or eliminated and a well applied coating job is assured.

Write on your company letterhead for free copy of the Amercoat Protective Coating Specification Guide.

Amercoat® CORPORATION

120A

Dept. VC,
4809 Firestone Blvd.
South Gate, California

921 Pitner Ave. Evanston, Ill.
360 Carnegie Ave. Kenilworth, N.J.
2404 Dennis St. Jacksonville, Fla.
6530 Supply Row Houston, Texas

Building . . .

months, and the final decision to build was announced in November. Construction of the phenol plant is Dow's first step in developing an integrated chemical and plastics manufacturing operation in the Northwest. This operation is to be built over a period of several years to produce various chemical materials.

Sunland Refining Corp. has placed on stream at Bakersfield, Calif., a 400-bpd Merox unit for treating thermally cracked gasoline. The Merox process, developed by Universal Oil Products Co., is used by Sunland for continuous mercaptan extraction with caustic regeneration followed by continuous solid bed Merox sweetening. The product is doctor sweet.

Dow Chimica Italiana S.p.A. has been formed and will construct a multimillion-dollar manufacturing plant in Italy. The wholly-owned Dow Chemical Co. subsidiary reports that plans for the plant site have not been finalized. A number of products are being considered for production, one of which is Dow's line of polystyrene plastic.

U.S.S.R. is planning construction of an acetylene plant. The Soviet company Techmashimport has contracted with the Belgian company Etudes et Recherches Industrielles (E.R.I.) for construction of the unit. Engineering and licensing is being handled by Societe Belge de L'Azote Produits Chimiques du Marly (S.B.A.), Liege, Belgium.

Ethyl Corp. plans to construct a vinyl chloride monomer plant at its Houston manufacturing center. The Houston plant will supplement the company's vinyl chloride monomer plant at Baton Rouge, La. Construction work on the new installation is expected to start soon, and completion is scheduled for early in 1961.

Nihon Synthetic Rubber Co. has completed its new $33.3-million petrochemical center at Yokkaichi, Japan. The plant's production is expected to reach 45,000 tons by 1963. The company plans to manufacture its own butadiene from butane and butylene supplied by Daikyo and Showa oil companies. Mitsubishi Petrochemical Co. will supply styrene.

Borden Chemical Co. plans to construct a 40-million-pound-per-year polyvinyl chloride plant at Illiopolis, Ill. The unit will produce a complete line of copolymer and polyvinyl chloride products. It will also include facilities for polymerization reaction, raw material storage, drying, blending and compounding. The installation will cost about $4 million.

India will build a 500-ton-per-day urea plant, reportedly the world's largest, at Neyveli, about 140 miles from Madras on the Indian peninsula. Italy's Montecatini Co. and Ansaldo Co. have contracted with India's Neyveli Lignite

For more data on advertised products, use Readers' Service Cards, last page.

Trainees using Rockwood Double Strength FOAM liquid learn one of the most effective fire-fighting techniques ever developed. Training cost is low because 3 gallons of FOAM provide 1,000 gallons of extinguisher.

Training men with Rockwood FOAM costs you least, saves you most

Rockwood Double Strength FOAM liquid gives you more efficient fire protection at lower cost than any other fire extinguishing agent. By mixing only 3 gallons of FOAM liquid with 97 gallons of water and 900 gallons of air you get 1,000 gallons of a powerful fire-fighting mixture — *the cost of which, per gallon, is only three tenths of 1% of the cost of FOAM.*

Double Strength FOAM liquid helps you improve and economize your departmental training too. The very small proportion required to produce this extinguishing agent permits training under actual fire conditions at negligible cost.

For further facts on Rockwood Double Strength FOAM, tested and listed by Underwriters' Laboratories, Inc., send coupon today.

ROCKWOOD SPRINKLER COMPANY
A Division of The Gamewell Company

Engineers Water... to Cut Fire Losses

Distributors in all principal cities

ROCKWOOD SPRINKLER COMPANY
A Division of The Gamewell Company
Portable Fire Protection Division
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Please send me your illustrated booklet on Rockwood fire-fighting products.

Name _____

Title _____

Company _____

Street _____

City _____ *Zone* ___ *State* ___ ___

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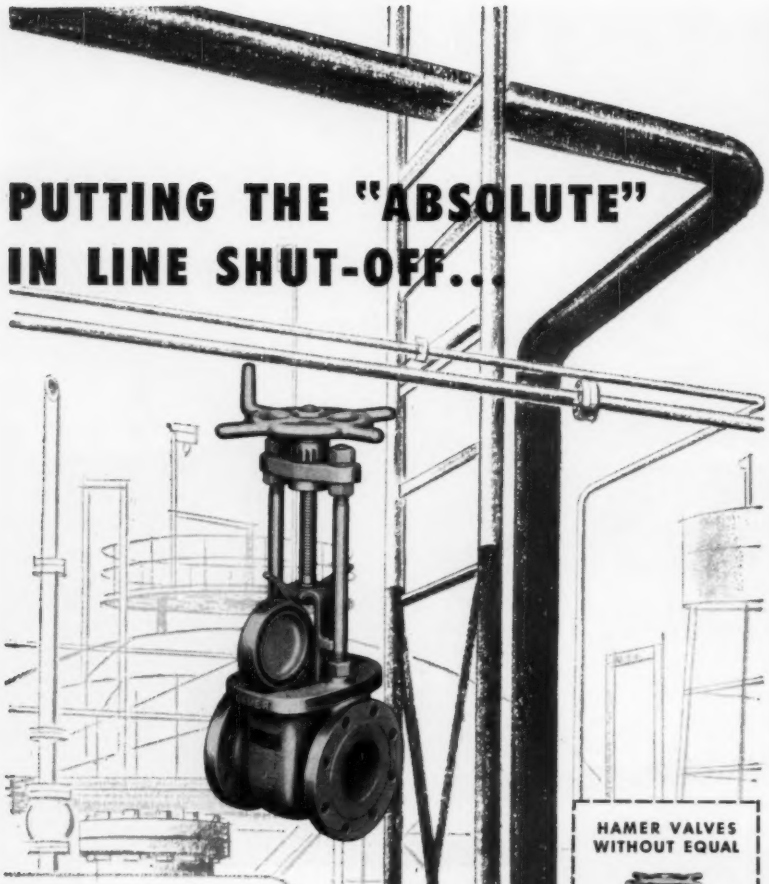


PUTTING THE "ABSOLUTE" IN LINE SHUT-OFF...

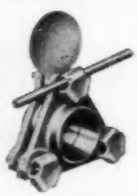
Hamer Line Blind Valves

It has long been recognized that convention type valves do develop leaks. And contamination of product when it occurs costs dearly in time and money. Preventing this is where Hamer Line Blinds excel. Handwheel or bar operated, Hamer Line Blind Valves squeeze dead tight against the center spectacle plate forming an impassable line shut-off that's both permanent and absolute. Yet Hamer Line Blinds are fast, safe, simple to operate. One man can open or blind a line in one minute. Investigate Hamer Line Blinds. Let a Hamer representative show you how these remarkable valves can actually pay for themselves.

SEND FOR FREE CATALOG

HAMER VALVES WITHOUT EQUAL

Leak-proof Gate Valve



Line Blind Valves

Lift-type Plug Valve

WELL EQUIPMENT MFG. CORP.

HOUSTON, TEXAS

DIVISION OF CHIKSAN COMPANY

Building . . .

Corp. to build the $21-million plant. Montecatini will construct and design the plant, which will employ the Fauser-Montecatini process. Germany's Pintsch-Bamag Co. will provide lignite-drying and gasification equipment, and Linde Co. will provide air-distillation nitrogen capacity. The $52.5-million facility will be completed by early 1963.

Oronite Chemical Co. plans to team with Societe Californie-Atlantique in construction of a p-xylene plant at Donges, France, on the Loire River near St. Nazaire. The latter company is a new French firm being formed by Antar Petroles de l'Atlantique (a French petroleum organization) and Societe Progil (a French chemical company). To be completed this year, the plant will be operated by Californie-Atlantique.

British Petroleum Co. is installing equipment for production of special solvents at its Kent, England, refinery. To be the first such plant in the United Kingdom, it will have a capacity of 30,000 tons per year. The plant consists of a redistillation unit and acid washery, tankage, lines, loading facilities and pumps. It is to be completed this year.

Refineria Petrolera de Guatemala plans to team up with Oronzio de Nora and Phillips Petroleum Co. to build a 12,000-bpd refinery at Matias de Galvez in Central America. The plant would be Central America's second. The first is currently under construction at the same location by Matias de Galvez, Ltd. (See PETROLEUM REFINER, February 1960 issue, page 182).

Amoco Chemicals Corp. has cancelled its plans to construct a plant at Joliet, Ill., to manufacture conventional and high-impact polystyrene on a large-scale basis. The company said plans were changed in view of "some recent developments." Plans to build a semiworks plant for polystyrene at Joliet remain unaltered. The unit is to come on stream this month.

The Dow Chemical Co. is planning a major increase in styrene monomer production capacity, at Freeport, Texas, and Midland, Mich.

The new production program will bring Dow capacity to more than 800 million pounds per year. Completion is expected by late 1960 or early 1961.

Canadian Chemical Co., Ltd. is planning to expand its Edmonton, Alba., refinery. The project is expected to cost about $4 million. The company is currently producing methanol, formaldehyde, acetic acid, pentaerythritol and solvents.

Sumitomo Chemical Co., Ltd. plans to build an acetylene-ethylene plant in Niihama City, Japan. The plant will be jointly owned with Societe Belge de

For more data on advertised products, use Readers' Service Cards, last page.

• The Skelly Oil Company kept the area around these butane-propane storage tanks completely free of weeds for a whole season by spraying the ground with Du Pont "Telvar".

Get season-long control of fire-hazardous weeds —spray once with a Du Pont Weed Killer

No fire hazard here from weeds. No expensive or difficult weed-control program, either. Just a simple weed-control maintenance program with a Du Pont weed killer kept the area around these storage tanks clean. One spraying of Du Pont "Telvar" monuron or "Karmex" diuron weed killers provides safe, economical weed control around refineries, storage tanks, pipelines and producing fields for a season or longer. Fire hazards are eliminated.

Five-year records of several petroleum companies show that Du Pont "Telvar" and "Karmex" cut weed-control budgets from 50 to 75%. "Telvar" and "Karmex" are non-flammable, non-volatile, non-corrosive and low in toxicity to man and animals. Contact Du Pont for information on which weed killer is best suited to your soil type and moisture conditions—write Du Pont, 2543 Nemours Bldg., Wilmington 98, Delaware; in Canada: Du Pont of Canada Ltd., P. O. Box 660, Montreal, Quebec.

On all chemicals, always follow label instructions and warnings carefully.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

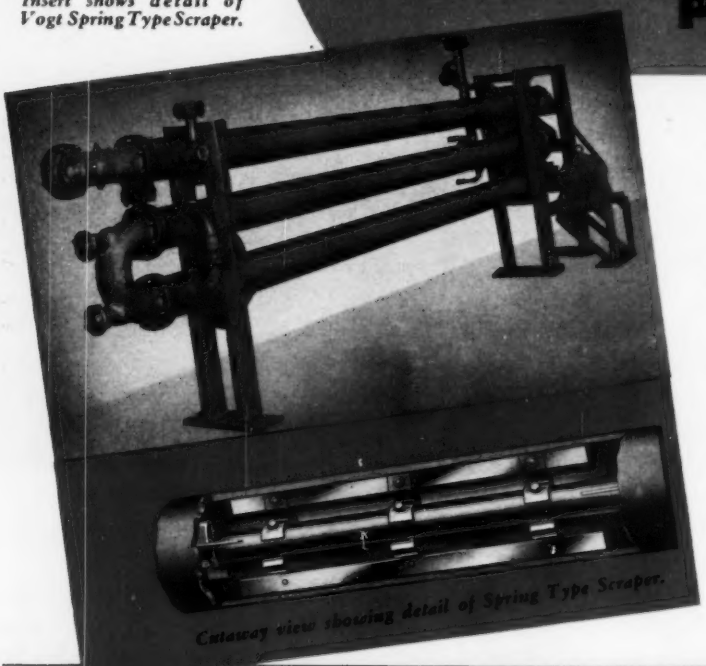
Weed and Brush Killers

TELVAR® monuron weed killer · **KARMEX**® diuron weed killer · **AMMATE**® **X** weed and brush killer · **TRYSBEN**® **200** weed killer · **DYBAR**® fenuron weed and brush killer

Vogt

SCRAPED SURFACE EXCHANGERS *Solve* those Special Heat Transfer and Crystallization Problems . . .

BELOW: *A scraped surface unit for production of Para-Xylene by fractional crystallization. Insert shows detail of Vogt Spring Type Scraper.*



Cutaway view showing detail of Spring Type Scraper.

. . . *And Here's How:*

1. Rotating scraper action continuously sweeps surfaces clean even while processing highly adhesive materials.
2. Uniform rate of heat transfer keeps crystallization under control and discharges crystals as a slurry.
3. Product is thoroughly mixed by scraper blades as it flows.
4. Closed, pressure-type system permits use of flammable, volatile and expensive solvents with complete safety and no solvent loss.
5. Units fabricated from a broad range of materials to suit process stream characteristics.

Write for Literature. Address Dept. 24A-XPR

Listed here is a wide variety of materials which have been successfully processed with Vogt Scraped Surface Exchangers in the chemical, petro-chemical, petroleum and related industries.

Benzene Hexachloride
Caustic Soda
Caustic Potash
Clay
Cylinder Stock
Para-Dichlorbenzene
Fatty Acid Solutions
Fish Oil
Linseed Oil
Naphthalene
Paratone & Solids
Phenolic Resins
Polyester Liquid
Pressed Distillate
Reduced Petroleum
Waxy Oil-Solvent Mix
Soybean Oil
Sperm Oil
Sugar Syrup
Sulfur-Oil Mix
Sulphate Solution
Tall Oil-Naphtha-Sulfuric Acid Solutions
Tetrachloro Benzene
Viscose
Wax Slurry
Para-Xylene

HENRY VOGT MACHINE CO.
Louisville 10, Ky.

SALES OFFICES:
New York, Chicago, Cleveland, Dallas, Camden, N. J., St. Louis, Charleston, W.Va., Cincinnati

Building . . .

L'Azote Produits Chimiques du Marly (S.B.A.), Liege, Belgium. Construction of the unit has been authorized by the Japanese government. The plant, which will be the first in Japan for the simultaneous production of acetylene and ethylene by pyrolysis of liquid hydrocarbons, is to be designed and built by S.B.A.

Shell Chemical (Australia) Pty. is about to begin construction of a $22.4 million ethylene plant at Clyde, near Sydney, Australia. The plant is scheduled for completion in 1962. Ethylene will be piped 12 miles to Imperial Chemical Industries, Inc.'s polyethylene plant, completed in 1957. ICI will up capacity there to 25,000 tons a year, changing over from ethanol.

U.S.S.R. is planning construction of two ammonia plants. The Soviet company Techmashimport has contracted with the Belgian company Etudes et Recherches Industrielles (E.R.I.) for construction of the unit. Engineering and licensing is being handled by Societe Belge de L'Azote Produits Chimiques du Marly (S.B.A.), Liege, Belgium.

International Synthetic Rubber Co., Ltd., plans to up capacity of its Hythe, England, plant, near Southhampton, from 70,000 to 90,000 tons per year of butadiene-styrene-type rubber. The increase is attributed to a "speedup of operations, rather than additional capital outlays."

Shell Italiana plans to add a 100,000-ton-per-year plant to the Rho refinery, near Milan, for fractionation and extraction of aromatic solvents. Shell and Condor Co. hold joint ownership of the project. The plant is to be completed by the middle of 1961.

Oronite Chemical Co. has begun construction of its multimillion-dollar maleic anhydride plant at Richmond, Calif. The 20-million-pound-per-year installation is being built by Badger Manufacturing Co., which has scheduled completion for the middle of 1960.

Communist China reportedly has completed construction of a 20,000-bpd refinery at Lanchow. Built with equipment from the U.S.S.R., the plant is Red China's biggest. Another refinery is currently under construction at Shenyan, Northeastern China.

Leuna-Werk Walter Ulbricht, East Germany, plans to construct new plants for urea and ammonium nitrate production. The organization also plans to increase nitrogen capacity from 300,000 tons per year to 400,000. This expansion is to be complete by 1965.

Dow Badische Chemical Co. has completed its new acrylic monomer plant at Freeport, Texas. Acrylic acid is being manufactured as a 94 percent

20% lighter than cotton duck but just as sturdy and flexible... Quaker Thermoid OS&D Hose

Strong but light. Extremely rugged but flexible. That's Thermoid-Quaker "Quaflex" Oil Suction and Discharge Hose.

It's lighter than reinforced cotton-duck hose, but it won't expand under pressure. It won't collapse under suction. It's exceptionally kink- and crush-resistant.

For more details, call your local Thermoid distributor, or write to *Thermoid Division, H. K. Porter Company, Inc., Tacony and Comly Streets, Philadelphia 24, Pa.*

HERE'S WHY: Separate layers of nylon tire cord surround a helix of high-tensile spring-steel wire in Thermoid-Quaker "Quaflex" Oil Suction and Discharge Hose. That's why it's just as sturdy and flexible as cotton duck, although lighter in weight.

Nylon tire cord for lightness, strength.

THERMOID PORTER DIVISION

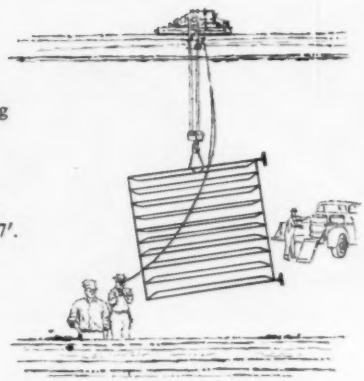
H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION, PEERLESS ELECTRIC DIVISION; Specialty Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

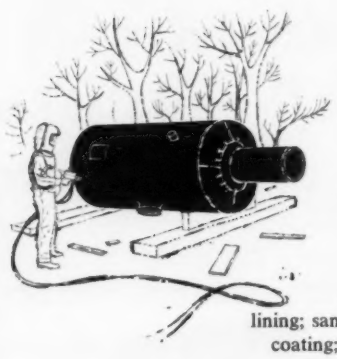
For more data on advertised products, use Readers' Service Cards, last page.

Nowery J. Smith Co. has the atmospheric corrosion prevention service you require

HOT-DIP GALVANIZING• Nowery J. Smith Co. is the most experienced galvanizer in the Southwest. Professional galvanizers assure that complex shapes, inside surfaces, and hard-to-reach areas—all—receive the same durable zinc coating. Applied according to ASTM or your own specifications.



PICKLING• For scientifically cleaning ferrous metals and stainless steel fabrications Nowery J. Smith Co. operates a complete pickling farm. Farm is equipped with seven pickling tanks in sizes up to 39′ 6″ by 3′ 4″ by 7′.



SPECIAL COATINGS• For structures and equipment requiring the protective advantages of zinc, aluminum, or other hot metal coatings, Nowery J. Smith Co. offers a complete metallizing service—applied in its plant or at your job-site. Additional special coatings and metal surface services include: Plioweld rubber lining; sand or shot blasting; painting; oiling; prime coating; epoxies and other task-tailored coatings.

When your next corrosion prevention problem arises, discuss it with a sales engineer from Nowery J. Smith Co., the Southwest's most complete corrosion prevention center. There's no obligation. Write, wire, or call:

LARGEST HOT-DIP GALVANIZERS IN THE SOUTHWEST

NOWERY J. SMITH CO.

8000 HEMPSTEAD HIGHWAY • P. O. BOX 7398 HOUSTON 8, TEXAS • UNderwood 9-1425

ONE OF THE SMITH INDUSTRIES —

Building . . .

technical grade. The process involved was developed by Badische and is believed by the company to be new to the U. S. chemical scene. Acrylic esters are produced by esterification with methyl, ethyl, butyl and other alcohols. The $6-million company is owned jointly by Dow and BASF Overzee, N. V., a subsidiary of Badische Anilin-& Soda-Fabrik AG of Ludwigshafen a. Rhein, Germany.

Delhi-Taylor Oil Corp. has started construction of a 3-million-gallon-per-year ortho-xylene fractionation plant at Corpus Christi, Texas. To be completed by July, the unit was engineered by Universal Oil Products Corp. and Delhi-Taylor. The latter company handled construction.

Reichold Chimie A.G. plans to construct a petrochemical plant at the North Sea port of Brunsbuettelkoog. Reichold's partner in the joint project is Deutsche Erdoel (Hamburg), German independent refiner. The type of petrochemicals to be produced was not revealed.

Northern Natural Gas Co. has begun an expansion of its Spearman, Texas, gasoline plant from 100 to 200 MMcf per day. Construction is being handled by Dresser Engineering Co., and is to be completed by July 1960.

Yacimientos Petroliferos Fiscales, Argentina's state-owned company, has opened bids for construction of lube oil, gasoline processing, and reforming plants at its Campo Duran field in Argentina.

CA Nacional de Grasas Lubricantes, a Venezuelan company, has started operations of a lubricating grease plant at Valencia, Venezuela. Production capacity of the unit is 1.3 million pounds.

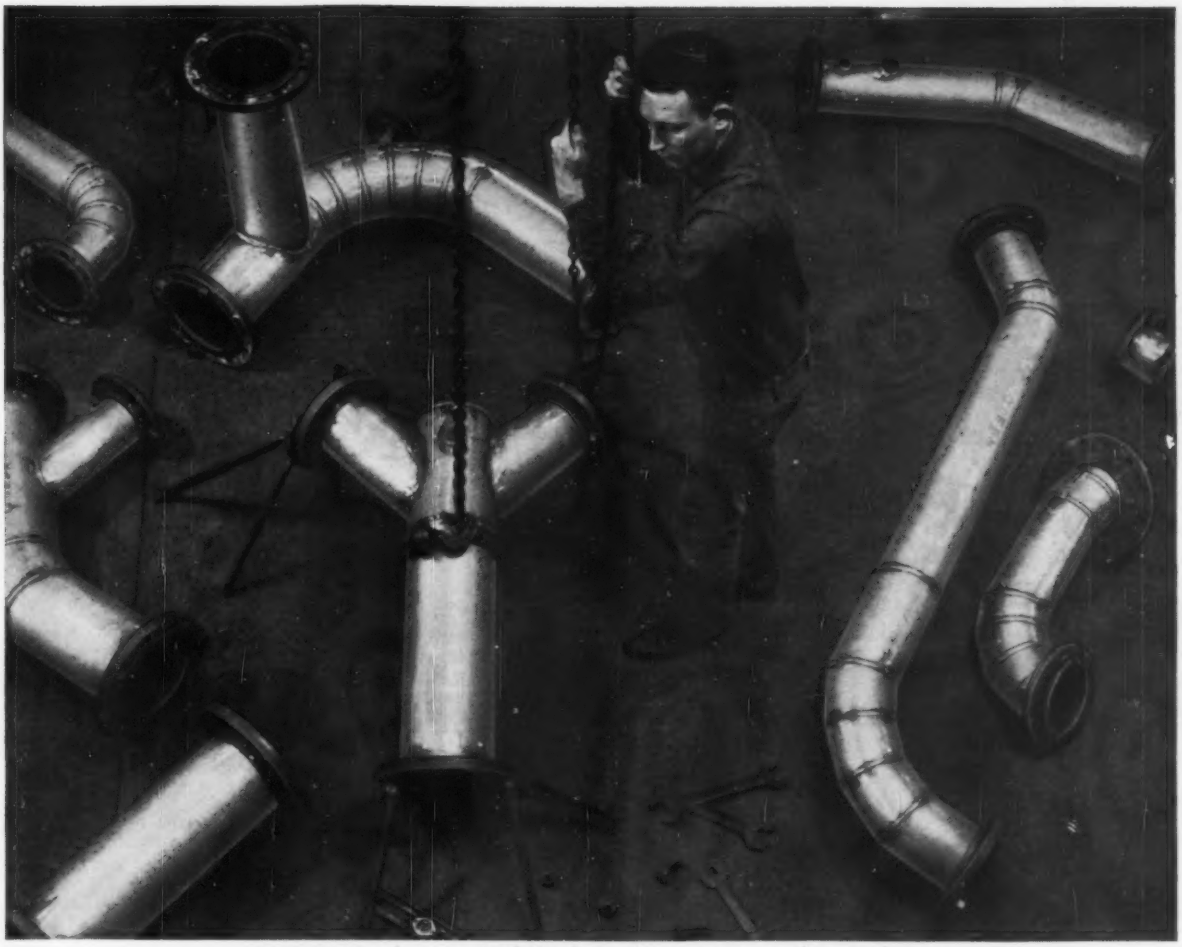
British Petroleum Co. and Shell Oil Co. plan to jointly construct a $70-million refinery by 1963 at Reunion Rocks, near Durban, South Africa. The project would cost about $70 million.

Sun Oil Co. has put into operation a $1.2-million hydrodesulfurizer for hydrogen treatment of heating oils. The unit was installed at the company's Marcus Hook, Pa., refinery.

Allied Chemical Corp. is planning to build a 56,000-ton-per-year ammonium sulfate plant at El Segundo, Calif. The unit is to be completed by late this year.

Piesteritz Nitrogen Works, East Germany, plans to increase its nitrogen capacity to 20,000 tons per year. Construction is to be completed by 1961.

For more data on advertised products, use Readers' Service Cards, last page.



CUPRO NICKEL salt water circulating line sections to serve auxiliary condensers aboard gypsum rock carriers recently fabricated by Boro Marine & Industrial Corp.

Wide variety of Cupro Nickel piping for salt water lines is readily made from sheet by welding

Circumferential joints are welded manually. Longitudinal seams are welded in mechanized equipment by inert-gas, metal-arc processes.

Ever higher velocities in salt water lines and the growing economic importance of continuity in service, on shipboard, and also in tidewater power plants and oil refineries, are leading to increasing use of Cupro Nickel in piping.

Techniques and skills for economical fabrication of even the most complicated elements of Cupro Nickel piping systems are keeping pace. Boro Marine & Industrial Corp., Port Richmond, Staten Island, N. Y., a specialist in the field, forms piping in sizes 6″ to 24″ diameter from Anaconda Cupro Nickel stock sheet, usually 48″ x 96″ x 3/16″. Elements shown above indicate the variety possible. Seamless tubing is used for smaller diameters.

Boro Marine fabricates piping from both Cupro Nickel 30%-702 and Cupro Nickel 10%-755. The trend, however, is to Cupro Nickel 10%-755 for the majority of salt water line installations on commercial vessels and in industrial jobs, according to M. E. Wuensch, president. The alloy was developed by Anaconda for this kind of service. It is resistant to corrosion by both clean and polluted sea water, even at relatively high velocity of flow, and is resistant to corrosion by sea water containing air bubbles.

TECHNICAL ASSISTANCE. For help in selecting the alloy best suited for a particular job in heat transfer and piping systems, call in your American Brass representative, or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6086

ANACONDA®

CUPRO NICKEL MILL PRODUCTS

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WARREN QUALITY

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Gives you **Dependable Deliveries of**

Natural Gasoline

Whatever the GRADE, Whatever the VOLUME

WHEN you want it
WHERE you want it and the
WAY you want it

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Higher Prices Essential to Better Earnings

(All "per share" data are based on the number of shares of common stock outstanding Dec. 31, 1959)

COMPANY	4TH QUARTER $ Thousand 1959	4TH QUARTER $ Thousand 1958	4TH QUARTER $ Per Share 1959	4TH QUARTER $ Per Share 1958	4TH QUARTER % Dif.	YEAR $ Thousand 1959	YEAR $ Thousand 1958	YEAR $ Per Share 1959	YEAR $ Per Share 1958	YEAR % Dif.
Anderson-Prich	2,018	1,089	1.15	0.60	+ 85	6,885	3,846	3.90	2.08	+79
Ashland O. & R.	3,627	3,232	0.53	0.46	+ 12	14,744	9,989	2.13	1.35	+48
Atlantic Ref. Co.	6,199	16,950	0.65	1.84	— 63	30,174	36,130	3.19	3.86	—16
Continental Oil	14,970	14,537	0.71	0.69	+ 3	60,300	48,400	2.85	2.29	+25
Gen. Amer., Tex.	1,088	2,291	0.33	0.68	— 52	4,927	6,397	1.47	1.91	—23
Gulf Oil Corp.	73,525	125,140	0.73	1.25	— 41	290,000	329,533	2.90	3.29	—12
*Imperial Oil	16,720	16,173	0.52	0.51	+ 3	54,400	50,620	1.72	1.61	+ 7
*International Pet.	7,800	3,900	0.54	0.27	+100	23,600	17,000	1.62	1.17	+39
Leonard Refineries	274	281	0.25	0.26	— 2	1,340	1,488	1.20	1.33	—10
Maracaibo Oil	51	119	0.10	0.24	— 57	244	337	0.50	0.69	—28
Ohio Oil Co.	11,310	9,128	0.81	0.65	+ 24	38,633	32,156	2.76	2.30	+20
Phillips Pet. Co.	26,614	26,591	0.77	0.77	.....	104,000	84,200	3.03	2.45	+24
Plymouth Oil Co.	d610	1,712	.....	0.64	.....	2,186	4,588	0.84	1.79	—52
Quaker State Oil	564	550	0.68	0.67	+ 3	2,328	1,890	2.82	2.29	+23
Shell Oil Co.	43,345	39,551	0.72	0.65	+ 10	147,400	128,583	2.43	2.12	+15
Sinclair Oil Corp.	10,475	14,132	0.68	0.92	— 26	45,500	49,473	3.00	3.23	— 8
Socony Mobil	39,600	47,386	0.82	0.98	— 16	162,600	156,786	3.35	3.23	+ 4
Standard, Calif.	73,885	70,015	1.17	1.11	+ 6	254,000	257,759	4.01	4.08	— 1
Standard, Ind.	33,411	31,326	0.93	0.88	+ 7	139,600	117,775	3.90	3.29	+19
Standard, Ky.	3,543	3,611	1.36	1.39	— 2	14,726	14,053	5.65	5.40	+ 5
Standard, N.J.	149,000	167,500	0.69	0.78	— 11	626,000	562,500	2.91	2.72	+11
Standard, Ohio	7,102	6,570	1.43	1.32	+ 8	25,061	24,044	5.02	4.82	+ 4
Sun Oil Co.	10,693	9,439	0.87	0.77	+ 13	42,844	32,061	3.48	2.60	+34
Texaco Inc.	92,146	82,838	1.52	1.37	+ 11	354,000	311,155	5.85	5.14	+14
Texas Gulf Prod.	1,301	1,446	0.33	0.35	— 10	4,180	3,970	1.04	0.98	+ 5
Texas Pac. C. & O.	2,014	2,065	0.52	0.59	— 2	7,197	6,231	1.85	1.67	+16
Wilcox Oil Co.	315	324	1.00	1.04	— 3	983	910	3.14	2.91	+ 8
*Total 25 Companies	606,460	677,823	.....	.....	— 11	2,379,852	2,224,254	.....	.....	+ 7

* Imperial and International are excluded from totals, being included as affiliates of Standard (N.J.)
d Deficit.

Shown in the table are net earnings of some oil companies in the fourth quarter and the year of 1959 vs. 1958

THE FIRST QUARTER of 1960 is bringing a continuance of the unfavorable trend of earnings that the oil industry encountered in the fourth quarter of 1959.

Prices of petroleum products and crude oil are around their lowest levels of the industry's 1957-1960 recession. The low prices tend to cancel the benefits of the continuing increases in volumes of business, as petroleum demand sets new records.

Oil industry earnings were at their lowest levels of recent years in the first and second quarters of 1958. They improved in the third and fourth quarters of 1958. In the first and second quarters of 1959 they showed further sharp recoveries of about 20 and 30 percent, respectively, over one year previously.

But after mid-1959 oil earnings ceased to improve. In the third quarter of 1959 they were up only about 1 percent. In the fourth quarter of 1959 they were down about 11 percent from the final quarter of 1958 (see Table).

Thus, the latter half of 1959 was a disappointment for the oil industry, and the fourth quarter was especially disappointing. For the first half of 1959, earnings were up 26 percent over 1958. For the first nine months, the increase shrank to 16 percent. For the year as a whole, the improvement further dwindled to a gain of only 7 percent over depressed 1958.

The unfavorable oil earnings trend of the latter half of 1959 was caused only in part by the long steel strike, which reduced demand for industrial fuel oil and lubricants and probably lowered demand for gasoline. A major adverse factor was continuing weak markets for petroleum products, due to over-supplies. Also, December 1959 was warmer than normal, in contrast with the unusually cold December 1958. Sales of heating oils consequently lagged badly, and prices were depressed.

January and February 1960 brought continuance of warmer than normal weather in the principal oil-heating regions and persistence of depressed prices of heating oils. Gasoline meanwhile was in seasonally low demand, and its prices likewise were weak.

The continued unfavorable trends indicate that industry earnings of 1960 will fail to equal those of 1959, at least in the first quarter and probably also in the second quarter. In the third and fourth quarters of 1960 it will be less difficult to match year-earlier results, which were disappointing. Nevertheless, because of a poor start, the industry may be unable to earn as much in the whole year 1960 as it did in 1959.

Management Aid to Tech Writers Being Surveyed

A survey to find what management is doing to help technical people communicate better is being made by the Technical Writing Improvement Society. Underlying the survey is the desire to find why industry is not doing more to help its key professionals—particularly engineers—write better. Survey results are expected to show if the reasons are financial, lack of instructors, lack of books and other teaching materials, etc. Questionnaires are being sent by TWIS to more than 1,000 of the country's top firms in all industries and results will be published in June.

Military Consumption of Petroleum Products Told

Deliveries of major petroleum products from domestic and foreign supply sources to U.S. military agencies totaled 736,000 bpd in fiscal year 1959 and are programmed at 697,000 bpd in fiscal 1960, and at 705,000 bpd in fiscal 1961, says the department of the Interior's Office of Oil and Gas.

This report is the first of a series of quarterly reports on military liftings of petroleum products to be released by the Office of Oil and Gas, based upon data furnished by the Office of Petroleum Logistics Policy, Department of Defense.

Imports of petroleum products by military agencies for military use in fiscal 1959 were: Jet fuel, 38,000 bpd; distillate fuel oil, 11,000 bpd; and residual fuel oil, 40,000 bpd. Military imports in July-September, 1959, were: Jet fuel, 43,000 bpd; distillate fuel oil, 1,000 bpd; and residual fuel oil, 15,000 bpd.

New Contract for OCAW At Humble's Baytown Plant

OCAW Local 4-333 at Humble Oil & Refining Co.'s Baytown, Texas, refinery, has reached an agreement with Humble management on a one-year contract that provides for wage increases averaging 15 cents per hour. Both management and union representatives made statements that the agreement "is a good contract for employes and the company." Included among the contract's 30 provisions are:

- A "streamlined, two-rate" pay system calling for "increases for nearly everybody, ranging from 4 to 61 cents an hour."
- Craft lines in job classification and assignment provisions of contract.
- Two-phase employe training program.

San Francisco Will Be Scene of ISA Conference

San Francisco will be the host city for the Summer Instrument-Automation Conference and Exhibit of ISA May 9-12. Conference sessions, to be held in the Civic Auditorium, will develop the theme "High Speed Computing and Instrumentation for Process Control." Presentations will be devoted to concepts, techniques and applications of scientific equipment and methods utilized in many processes and industries.

Conference sessions include: Nuclear Instrumentation; Aeronautical Instrumentation; Sales Engineering Workshop; Standards and Practices; Aerosols and Condensation Phenomena Instrumentation; Air Pollution Instrumentation; Metals and Ceramics Instrumentation; Data Handling and Computation; Electronics Instrumentation; Measurement

Who Gets Hurt?

"Who gets hurt in industrial accidents?" is a question asked—and answered—by a new pamphlet published by the National Safety Council. Entitled, "Who Gets Hurt?"—it uses a humorous approach, multicolored cartoons and concise text to discuss on-the-job injuries. The 16-page pamphlet explains the type of worker most likely to be accident-prone, how workers and their families are hurt in accidents, where accidents happen, what injuries cost the worker and his family, and what you can do about accidents.

A single copy of "Who Gets Hurt?" may be obtained free from the National Safety Council, 425 N. Michigan Ave., Chicago 11.

EFCO's Four Point Program Provides:

- service-proved engineering design
- guaranteed job-ratings
- complete fabricating facilities
- technical service before, during and after installation

One reason that Efco does it *right* is its many years of experience in designing and fabricating heat-exchangers for the wide range of temperatures and pressures represented by ethylene plants and platinum catalyst reforming units. We are recognized specialists in handling all grades of carbon, alloy, and stainless steels, nickel, aluminum, and special low-temperature materials.

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ENGINEERS AND FABRICATORS, INC.

P. O. BOX 7395 • HOUSTON 8, TEXAS

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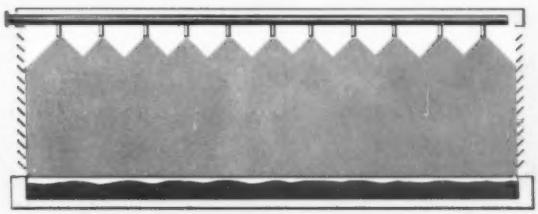
For more data on advertised products, use Readers' Service Cards, last page.

Should Process Plant Cooling Systems Use..

AIR ——————

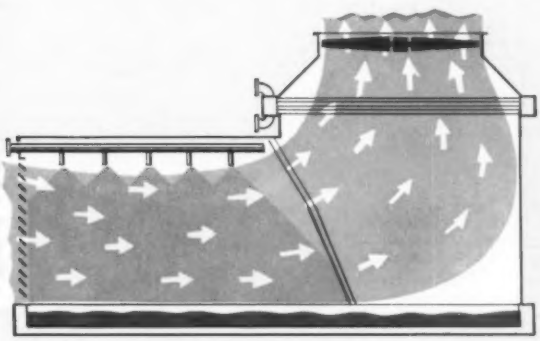
HUDSON SOLO-AIRE UNITS

WATER ——————



HUDSON COOLING TOWERS

or a combination of AIR AND WATER ——



HUDSON COMBIN-AIRE UNITS

The answer is found only through comparisons of economics of air, water or a combination of the two for cooling each process stream, and incorporating the results in one integrated cooling system. Factors to be considered include desired effluent temperature of each process stream; summer and winter ambient dry and wet bulb temperatures; availability and quality of water; possibility of public water pollution; space available; and first cost, maintenance cost, and operating cost of equipment.

HUDSON is unique in supplying water cooling towers, Solo-aire units, and Combin-aire units to comprise integrated cooling systems utilizing air and water in economic ratios. With the collaboration of owners' engineers, HUDSON has designed integrated cooling systems for a wide range of process and climatic conditions. Hundreds of HUDSON installations are operating in the United States, Ireland, England, France, Spain, Norway, Saudi Arabia, Pakistan, the Philippines, Mexico, Chile, Peru, Venezuela, and Canada. HUDSON experience, available without obligation in integrating the cooling system with process design, will be most valuable to plant owners if utilized during planning stages.

In early design stages of future projects let HUDSON collaborate with your engineers in selecting the integrated cooling system which best balances capital investment and operating cost for the specific process, climatic and water conditions.

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ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

ONLY HUDSON OFFERS ALL **3** *TYPES OF COOLING EQUIPMENT*

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to all NATURAL GASOLINE MEN

GREETINGS

from the

NATURAL GASOLINE SUPPLY MEN'S ASSOCIATION

We are looking forward to seeing you at the
THIRTY-NINTH ANNUAL CONVENTION
of the NATURAL GASOLINE ASSOCIATION of AMERICA
APRIL 27, 28, 29, 1960, RICE HOTEL
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Elliott Company
Engine Life Products Corp.
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Ethyl Corporation

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The Fish Engineering Corp.
The Fisher Governor Company
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The Fluor Corporation, Ltd.
Fluor Products Company
The Foxboro Company
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Gas Processing Associates
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General Controls Co.
General Electric Company
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The Griscom-Russell Co.
Grove Valve & Regulator Co.

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Nickles Machine Corporation
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Wm. W. Nugent & Co., Inc.
Nutter Engineering Co.

The Ohio Injector Co.
The Oil Daily
The Oil & Gas Journal
Oil Well Supply Div.—U. S. Steel Corp.
Olin Mathieson Chemical Corp.
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Tellepsen Petro-Chem Constructors
The Tennant Co.
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Thurmond-McGlothlin
Trinity Steel Company, Inc.
Tube Turns—Div. National Cylinder Gas Co.
Tuloma Builders, Inc.

Union Pump Sales Co.
United Centrifugal Pumps
United Chemical Corporation of New Mexico
Universal Oil Products Co.

Vinson Supply Company
Vulcan Steel Tank Corp.

Walco Engineering & Constr. Co.
Wesco Valve Co., Inc.
Western Chemical Co., of K. C., Mo.
Western Chemical & Supply Co.
Western Supply Company
Charles Wheatley Company
The Wickes Boiler Co.
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and Control Instrumentation; Analysis Instrumentation; Management and Economics; Physical and Mechanical Measurement Instrumentation; Feedback Control Systems; Educators' Workshop; Instrument Maintenance Clinic, and a Maintenance Management Workshop.

Thermodynamic Conference For Oklahoma State U.

A conference on thermodynamic and transport properties will be conducted by Oklahoma State University at Stillwater, Okla., April 18-19. Three noted industry lecturers, Wayne C. Edmister (author of PETROLEUM REFINER's current series on hydrocarbon thermodynamics), Dr. Daniel R. Stull and Dr. Y. S. Touloukian, will discuss thermodynamics of the first order, heat measurements, calculated thermodynamic properties, applications of thermodynamics, enthalpies and densities of hydrocarbon mixtures, transport properties, and needs for thermophysical properties. The thermodynamic and transport properties laboratory will be open for inspection during the conference.

Houston Ship Channel Fire Recalls 'Amoco Virginia'

Another fire in the Houston Ship Channel had hearts fluttering as memories revived the recent "Amoco Virginia" disaster. A tug boat and gasoline barge caught fire from a yet undetermined source, and the resulting gasoline fire on the water threatened the nearby Sinclair Oil Co. refinery. Fire departments from Houston and the channel area soon had the flames extinguished, however—quelching a potentially dangerous situation in Houston's gigantic processing area. Net result of the fire—one tugboat crewman badly burned swimming to shore in flaming waters—another missing and believed dead—tugboat completely destroyed—barge damaged and one-third of gasoline cargo burned off.

Close That Gap!

"Closing the Gap," a 10-page selected bibliography on science, education and careers for the science or engineering student, is available free as a public service through the Scientific Apparatus Makers Association. Compiled with the aid of the U.S. Office of Education and other professional societies and government agencies, this booklet provides the student with an abridged reference guide to some of the most worthwhile material on science. Formerly 25 cents, it is currently available free by writing to Scientific Apparatus Makers Association, 20 North Wacker Drive, Chicago 6.

Sales Exec Warns Against Excessive Film Capacity

Polyethylene film production capacity is currently 450 million pounds annually, says J. L. Rodgers, director of sales, Union Carbide Plastics Co. "This is double the capacity of only two years ago," he said. He warned that aggressive market development—particularly in the flexible packing field, which accounts for 75 percent of all polyethylene film—was necessary to overcome a serious overproduction problem and an accompanying poor profit picture.

While the use of polyethylene film—up 500 percent in the last five years—continues to be the fastest growing segment of the plastics industry, the industry's annual production capacity is more than 25 percent higher than total film use in 1959, he cautioned. "And the capacity will continue to increase during the coming year," said Rodgers.

Rodgers stated that the enormous rise in production capacity resulted in part from a three-fold increase in the number of film extruders since 1953, together with addition of new capacity by existing companies. Another important factor, he

NEW
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BREATHER VALVE
gives storage tanks
MAXIMUM FLOW and
MINIMUM VAPOR LOSS

T-1900 Breather Valve

This new Wheaton Type T-1900 "Quality Built" Breather Valve is thoroughly lab-tested and field tested for high flow rate and vapor tight control of vacuum and pressure.

Big advantages include diaphragms for both pressure and vacuum pallets . . . anodized aluminum bodies . . . large areas of flow spaces . . . easy inspection and maintenance.

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GET TIGHT, PRECISION EMERGENCY VENTING

For emergency venting of storage tanks, use the *Wheaton Type T-1950 Emergency Vent and Manhole Cover.* As required in A. P. I. Venting Guide, a diaphragm seal in cover assures positive seating.

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Manufacturers of Loading Arm Assemblies, Swing Joints, Loading Valves, Storage Tank Fittings and Truck Tank Equipment for the Petroleum and Chemical Industries.

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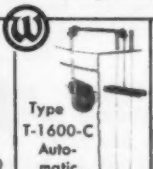
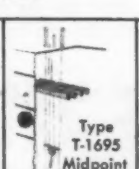
Install WHEATON fittings on your storage tanks

Type T-1550 Water Drain Valve

Type T-1600 Automatic Tank Gauge


Type T-1600-C Automatic Tank Guage


Type T-1695 Midpoint Thermometer

Type T-1700 Gauge Hatch

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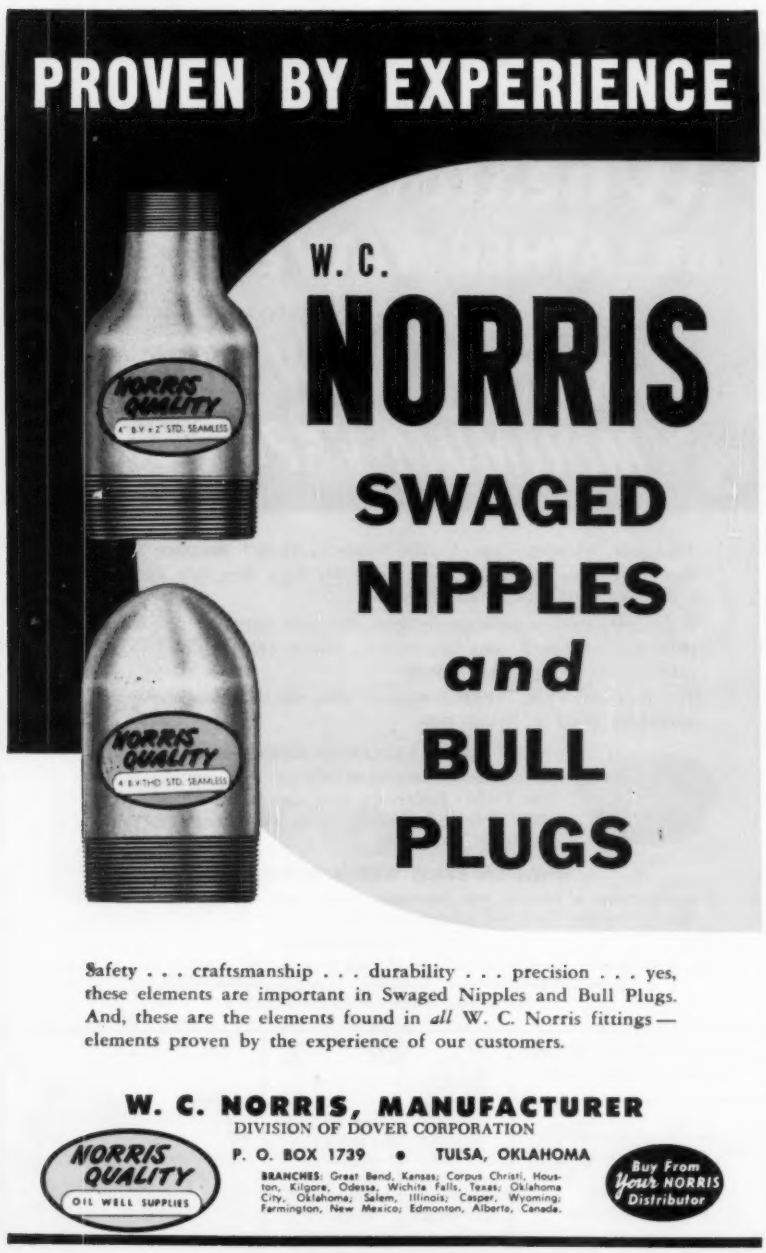
said, is the greatly increased productivity of modern extrusion machinery. "At one time, output rates of a 2½-inch extruder of 50 pounds of film per hour were quite common. The same size machine today often produces 100 pounds per hour."

New Cost Bibliography Is Announced by AACE

Plans to prepare and distribute an annual bibliography of published cost data has been announced by the American Association of Cost Engineers and the Department of the Interior. To be published annually as a Bureau of Mines Information Circular, it will consist of abstracts of articles appearing in technical and industrial magazines and government publications. Articles covering all phases of cost engineering in petroleum and chemical plants and related facilities and giving such data as operating costs, capital costs and economic evaluations are to be abstracted for the bibliography.

AACE will contribute $200 annually to the Bureau, in addition to providing abstracts of articles from about half of the 20 technical magazines to be abstracted. The Bureau is to abstract the other half of the magazines plus all pertinent government publications, as well as supervise and prepare for publication the bibliography itself.



Safety . . . craftsmanship . . . durability . . . precision . . . yes, these elements are important in Swaged Nipples and Bull Plugs. And, these are the elements found in *all* W. C. Norris fittings — elements proven by the experience of our customers.

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Buy From Your NORRIS Distributor

1960 Gasoline Demand To Be Up 3.8 Percent

Total gasoline demand this year should run at a 4.3-million-bpd rate, up 3.8 percent over 1959, estimates E. I. du Pont de Nemours & Co. The increase, which the company's Petroleum Chemicals Division predicts may be the "largest for some years to come," hinges on improved domestic demand for motor gasoline. With sales of motor vehicles expected to be second only to the 1955 all-time peak, and a healthy increase in personal income encouraging more travel, "all signs point toward a good year" for gasoline producers and marketers, the company noted.

Total gasoline production also will be up in 1960, with the daily average forecast of 4.25 million barrels running about 4.1 percent ahead of 1959. Total gasoline stocks at the end of 1960 are forecast at 193 million barrels compared with 187 million barrels at the end of each of the last two years.

Domestic markets will account for most of the predicted 1960 demand, estimated at 4 million bpd of motor gasoline and 200,000 bpd of aviation gasoline. Export demand is expected to be only 25,000 and 35,000 bpd respectively, for motor and aviation gasolines.

Tiny 'Tom Thumb' Refinery May Be in the Future

A notable "Tom Thumb" refinery that can ride a truck piggyback may solve the problem of obtaining petroleum products for drilling operations in the jungle or desert, according to *Petroleum Newsnotes*, published every two months by API's Committee on Public Affairs. The miniature unit would process from 500 to 1,500 bpd of oil and require a crew of only two men per shift. Operating at night, the refinery could convert crude oil into gasoline, diesel and heavy fuel oil used for running small trucks and the oil rig and for other uses around the drilling site. Besides keeping drilling costs down, portable refineries could prove valuable in developing the energy potential of out-of-the-way areas which have some oil production but which cannot afford to build and maintain a large refinery.

'Think Before You Leap' In Buying Computers

Here is what the chemical industry has been advised to do before "leaping to buy" costly computer equipment:

- Seek lower-cost alternative solutions to the problems at every step of the way. (Bringing in someone unfamiliar with computer control possibilities is a big help.)
- Have a strong mathematician and/or statistician on the team.
- Seek out situations where there are uncontrollable independent variables (or random upsets) which change fairly rap-

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DEHYDRATION

DEGASIFICATION

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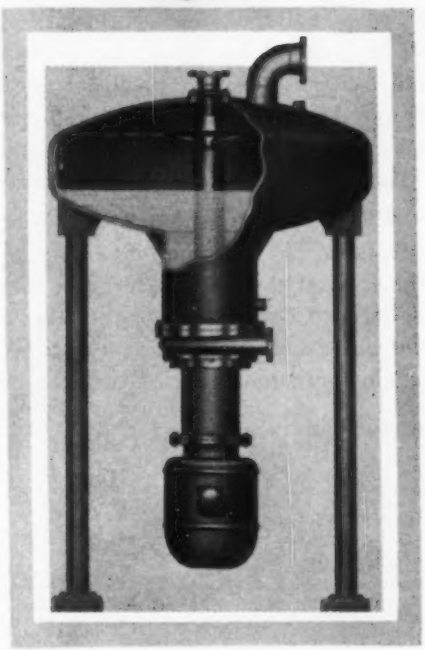
STRIPPING
FOAMING SOLUTIONS

STRATCO

VACUUM FLASH EVAPORATORS



These are but a few examples of the services in which **STRATCO** Flash Evaporators are being used. If you have a problem involving removal of relatively small amounts of volatiles from higher boiling point liquids, a **STRATCO** may be the answer.

Stratco
Flash
Evaporators feature:

. . . *enormous liquid surface area exposure*

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CELANESE CELLULUBES used as air compressor lubricants step up safety in new missile submarines...

The advantages of Celanese Cellulubes were clearly apparent after a test program by Electric Boat Division. The tests included a study of lubricants dispersed in air under high pressure, followed by abrupt decompression. This results in a high-speed shock wave which can cause a violent explosion. Hydrocarbon lubricants proved highly vulnerable, but Cellulubes were so effective in resisting these extreme conditions that they will be used in all compressors in the new Polaris Fleet Ballistic Missile Submarines.

Cellulubes are not only outstanding for the prevention of fire and explosion, they give overall wear protection comparable to that of premium petroleum oils. The resistance of Cellulubes to carbon formation eliminates frequent scraping and cleaning of charred residues from valves and other internal parts of reciprocating compressors. Celanese Cellulubes can reduce maintenance requirements for compressors and often for downstream equipment as well. Celanese Chemical Company, a Division of Celanese Corporation of America, New York 16.

Celanese® Cellulube®

NEW 20-PAGE MANUAL...
shows you the causes of fire and explosion in compressed air systems, based on latest research. This booklet is intended to help plant engineers and management reexamine specifications in the light of the benefits that Cellulube fire-resistant lubricants offer. Send for your copy today.

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Please send me a copy of your manual on synthetic lubricants for air compressors.

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Like all other Polaris Fleet Ballistic Submarines, the U.S.S. GEORGE WASHINGTON uses Cellulube 550 for its air compressors. (Built by Electric Boat Division of General Dynamics Corporation, Groton, Conn.)

Cellulubes... Celanese CHEMICALS fire-resistant functional fluids

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CELANESE CELLULUBES

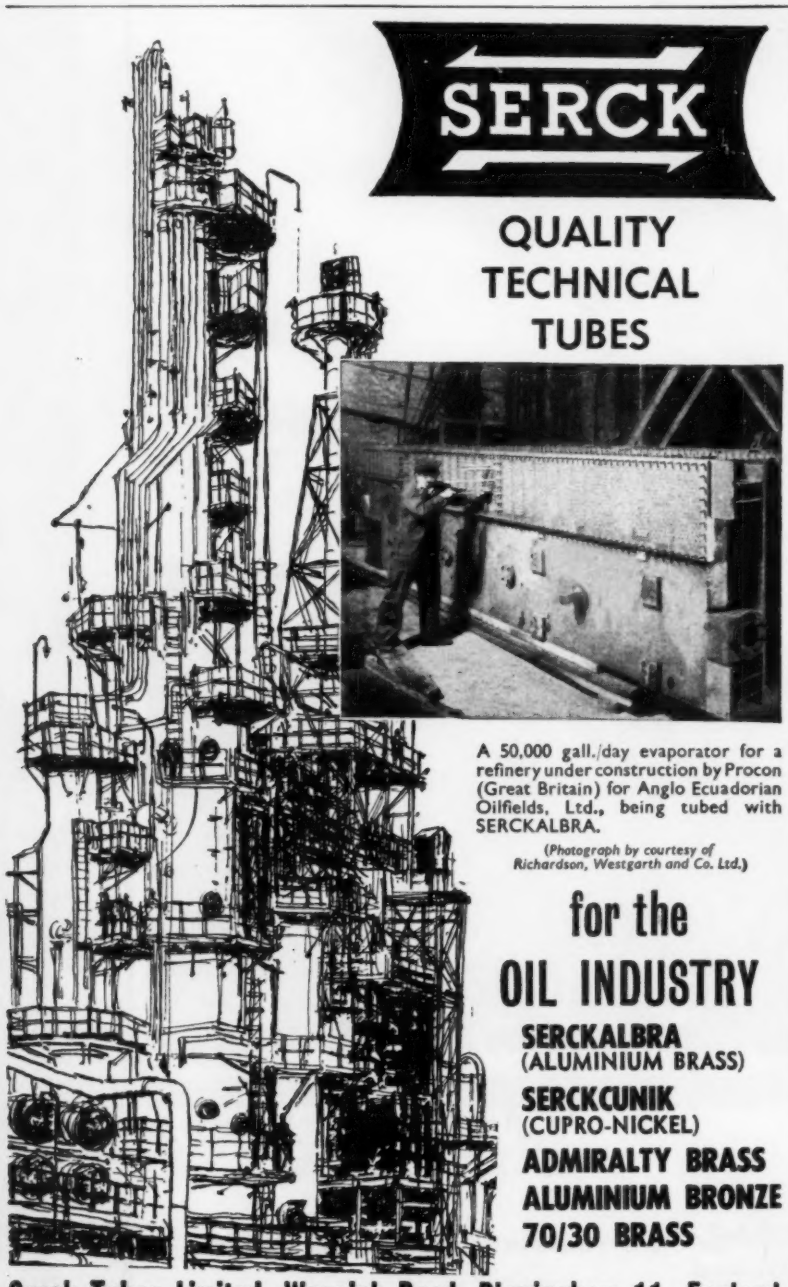
Happenings . . .

idly with time *and* where there are two or more controllable independent variables.

• Seek out interaction between independent variables upon the results desired. (If there is no interaction, there may be no real problem.)

The advice was given by C. R. Hall, of the Engineering Department, E. I. du Pont de Nemours & Co., Wilmington, Del., in a paper delivered at a symposium on computer control during the winter general meeting of AIEE .

Pointing to the furor caused by automation in other manufacturing processes and the doubtful results sometimes obtained, Hall said, "A similar stage appears to be set in the field of application of digital computers for control of chemical processes. There is much talk in broad generalities of the push-button plant; of a digital computer controlling vast chemical plants. There is much secrecy surrounding the specific applications that are in operation today—at least few published results of accomplishment."



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QUALITY
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A 50,000 gall./day evaporator for a refinery under construction by Procon (Great Britain) for Anglo Ecuadorian Oilfields, Ltd., being tubed with SERCKALBRA.

(Photograph by courtesy of Richardson, Westgarth and Co. Ltd.)

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Tax Exemptions for Co-ops Assailed by Petrolane VP

Wholesale tax erosion results from current practice allowing cooperatives wide exemption from federal income tax laws —and the most practical way to stop this loss is to tax the co-ops' net income before patronage dividends, according to John Wallace of Billings, Mont. Wallace spoke before the House Ways and Means Committee February 2 on behalf of the proprietary members of the national Liquefied Petroleum Gas Association. A vice president of Petrolane Gas Service, Inc., he told the committee that cooperatives have grown so rapidly in the LPG business that they "will soon dominate the LPG market with resultant additional tax erosion."

Citing several instances of co-op development in the butane-propane gas industry, Wallace said that the co-ops had long since passed out of the small farmer-organized group buying phase and should be recognized as big business. As such, he continued, co-ops should pay taxes on their net income just as do privately owned firms.

Wallace also cited in support LPGA's policy adopted last May which states that "the American system of free competition and free enterprise demands that each form of business enterprise should stand on its own merits without favoritism or benefit of government subsidy, either direct or through inequality of taxation." He urged repeal of Section 521 and 522 of the Revenue Act, thus denying any exclusion on patronage dividends.

Amoco Employes Are Safer on Job Than at Home

Employes at American Oil Co.'s Texas City refinery were 14 times safer on the job last year than they were in the home, according to Harvey Williams, safety supervisor for the plant. "According to an API survey," Williams explained, "workers in the oil industry were three and a half times safer on the job than they were in the home. Last year our employes were four times safer than the oil industry as a whole. Amoco figures show that employes at the refinery worked more than two and one-half million hours during 1959. During the first half of 1959, they suffered four lost-time injuries. During the second half when the strike was on, employes suffered no lost-time injuries on the job.

ISA Meeting to Feature 'Progress and Trends'

The theme "Progress and Trends" will be featured at the annual ISA Symposium and Chemical and Petroleum Instrumentation, to be held in the Hotel Sheraton, Rochester, N. Y., April 4-6. Papers and discussions will deal with current and future trends and problems of process instrumentation in the chemical and petroleum industries. More than a dozen papers will be presented by research, design and development engi-

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PROVED SAVINGS

in HYDROFLUORIC ACID alkylation

Have you looked at all the economic advantages of alkylation with hydrofluoric acid? Pennsalt's pioneering and specialization in AHF can help you realize big savings in your alkylation process: **1** Lower catalyst cost . . . **2** Elimination of spent acid problems . . . **3** Reduced acid inventory . . . **4** Lower cooling expense . . . **5** Shorter reaction time . . . **6** Faster catalyst settling . . . **7** Minimum side reaction products.

Pennsalt's expert technical aid will show you how to use and handle AHF safely and with confidence. We'll advise you on storage . . . on the selection of valves, pumps, piping and materials of construction . . . help you with employee training programs . . . give you personalized technical assistance tailored to your needs. Talk it over with your Pennsalt representative, or write for full information.

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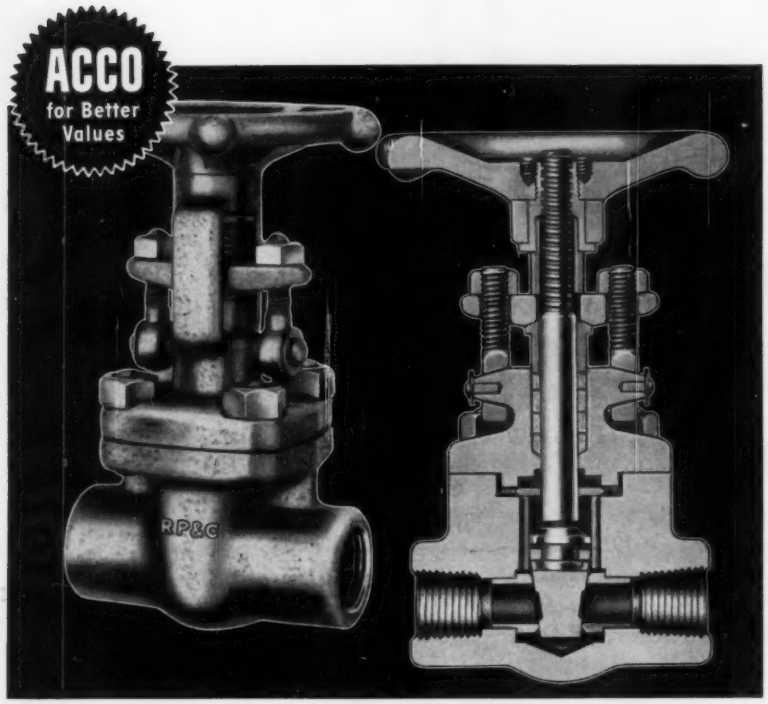

R-P&C gate and globe valves of FORGED STEEL

offer improved design...long life!

• You get these substantial benefits when you use R-P&C Forged Steel Gate and/or Globe Valves: a longer life of better service... a much lighter valve...plus the highest possible safety factor. New design and construction features make these advantages possible.

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These valves have been designed in cooperation with leading material specification engineers to meet the highest standards of service and safety. In designing these Forged Steel valves, special attention has been given to providing ample metal sections and a construction that eliminates unnecessary bulk and weight.

LONG LIFE

Here are some design features which add up to a long life of trouble-free service:

A. **Spiral-wound gasket in bolted bonnet joint**
B. **Careful heat treatment of parts for strength and wear**
C. **Unique stem design to protect stuffing box packing**
D. **High quality materials to prevent corrosion**
E. **Precision manufacture with exacting standards**

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R-P&C Distributors offer users in the petroleum industry—in addition to these outstanding Forged Steel valves—a complete line of R-P&C gate, globe and angle valves in all standard materials: electric furnace iron, bronze, bar stock, cast steel... plus many specialties. See your nearest R-P&C Distributor—or write—

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Happenings . . .

neers, operating engineers and management personnel from throughout the nation. The symposium is to be presented jointly by the Rochester Section of ISA, and the Chemical and Petroleum Industries Division of ISA. Keynote speaker is to be Marne A. Dubs, manager of the Engineering Laboratory, Linde Co., North Tonawanda, N. Y. The role of instrumentation in chemical plants of the future will be discussed. Emphasized will be the fact that instrumentation will greatly affect future plants from initial concept to their operation, culminating in automatic, unattended plant operation.

Domestic Crude Oil Demand Estimated for March - May

A half-million-bpd increase in U.S. petroleum demand has been forecast by the Independent Petroleum Association of America. Domestic demand for the period May-June should average about 9.65 million bpd—an increase of 367,000 bpd over the like 1959 period, according to the association's monthly supply and demand report. Total new supply needed from domestic production and imports during the next three months is estimated at 9.6 million bpd. This would involve a decrease of about 400,000 bpd from the estimated supply level during February, and 175,000 from the like 1959 period. Imports during the next three months are expected to average 1.65 million bpd compared with an estimated 1.87 million in February.

New Test Procedure for Motor Oil Performance

A laboratory test procedure to predict low-temperature field performance of compounded motor oils is being used by Oronite Chemical Co. The procedure involves more than eight million miles of road testing in various types of automotive engines. This provides a correlation between piston varnish deposits obtained in laboratory tests with oil-ring deposits in field engines. The new procedure is expected to minimize the need for future field testing, according to Oronite. Developed by California Research Corp., it is a modification of the standard 40-hour FL-2 engine test devised by the Coordinating Research Council.

Initial Step Taken in New OCAW Bargaining Drive

The initial step in a new collective bargaining drive in the oil industry has been taken by President O. A. Knight of OCAW. He has called on all local unions with petroleum bargaining units to elect delegates to area bargaining conferences. Knight said he hoped to convene area meetings this month in Washington, D. C., Chicago, Kansas City, Salt Lake City, and Houston or Dallas—each to last two days. Delegates to area conferences will

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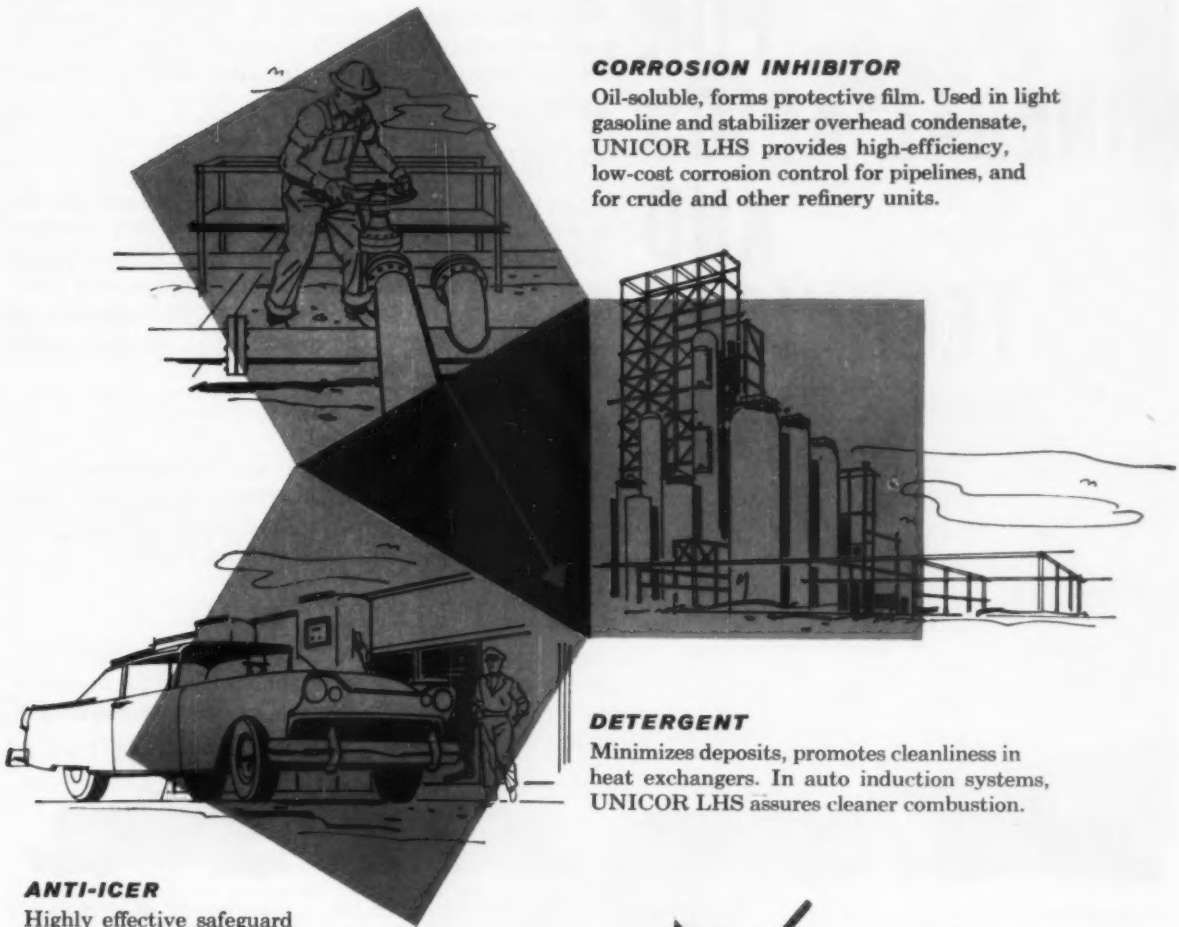
New... ...triple-purpose anti-icer

UNICOR LHS®

provides valuable refinery and pipeline service, too!



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MURIATIC ACID

Delivered in standard strengths of 18°, 20° and 22° Bé corresponding to 27.92, 31.45 and 35.21% HCl. Stauffer also offers an extremely high-purity, high-analysis grade of muriatic acid for food and other special uses. All grades are available in tank cars, tank trucks and carboys. Send for brochure on HCl; 44 pages with many graphs and tables.

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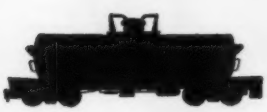
HCl delivered from Los Angeles, Richmond and San Francisco, Cal., Louisville, Ky., Baton Rouge, La., Henderson, Nev., No. Portland, Ore., Fort Worth and Houston, Tex. and Tacoma, Wash.



HNO_3 delivered from Los Angeles and San Francisco, Cal., No. Portland, Ore., Fort Worth and Houston, Tex.

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exchange ideas as to goals to be sought in negotiations with oil companies, then will elect two delegates from each of five areas to serve on a National Bargaining Policy Committee for Petroleum. These delegates will convene after area meetings are completed. This committee will draw up a coordinated collective bargaining program for oil. Areas established are: East Coast, Great Lakes, Mid-Continent, Gulf Coast and West Coast.

Latin American Oil Industry Theme of Mexico Meeting

Mexico City will be the scene this month of a meeting arranged by Mexico's President Lopez Mateos to discuss the interchange of products and technicians in the Latin American oil industry. Countries to be represented include Peru, Mexico, Argentina, Venezuela, Brazil and Chile. A Mexican government spokesman said Mexico stands to "help other Latin American countries expand state-controlled oil companies for refining, production, exploration and transportation."

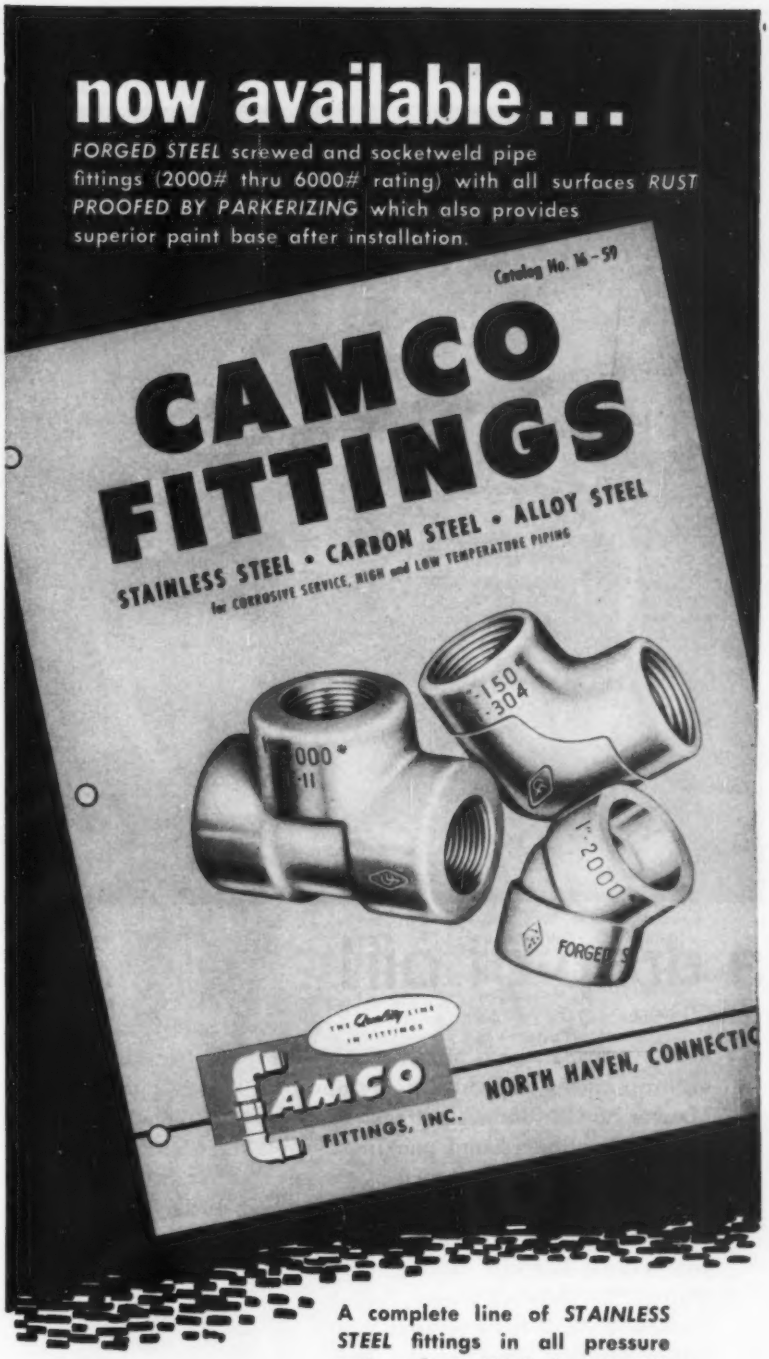
November LPG Production Shown by Bureau of Mines

Natural gas liquid daily production in November was 38.6 million gallons above October 1959, an increase of four percent, according to the Bureau of Mines. Average daily production of LPG at refineries was 7.8 million gallons, six percent above October. LPG demand for fuel and chemical uses in November increased 17 percent. LPG stocks reached 1.06 billion gallons, 135 million above the level for a year earlier. Underground stocks of LPG were down 122 million from October, to a total of 875 million gallons.

Gas Measurement Course To Be Held Next Month

The 1960 Southwestern Gas Measurement Short Course will be held April 19-21 at the University of Oklahoma, Norman, Okla. The principal speaker will be Wister H. Ligon, president of Nashville Gas Co., Nashville, Tenn., and 1960 AGA president. The three-day short course, held in cooperation with the Oklahoma University College of Engineering, will consist of 89 class sessions, both technical and non-technical. Instruction will be diversified to make the course interesting to everyone in gas measurement and related divisions of the natural gas industry. Programs may be obtained by writing Dean W. H. Carson, College of Engineering, University of Oklahoma, Norman, Okla. About 1,000 representatives of the natural gas, oil and allied industries are expected to attend the meeting.

In addition to class sessions, there will be a number of gas measurement equipment displays set up by various manufacturers. The 1960 short course will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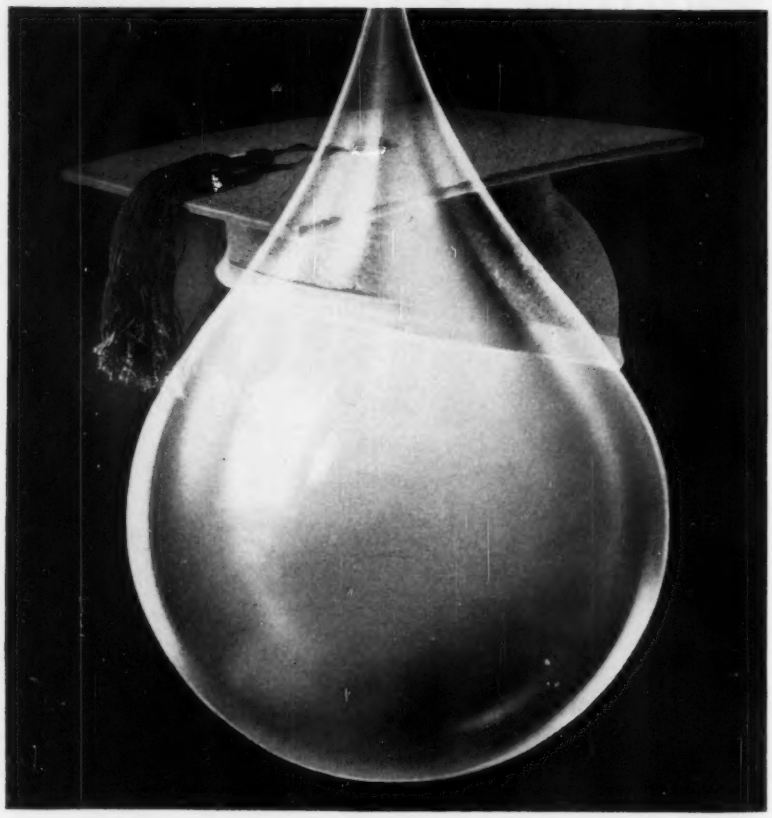
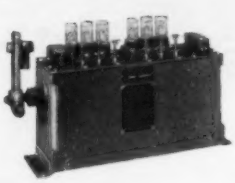
For more data on advertised products, use Readers' Service Cards, last page.

HOW TO educate



a drop of oil!

Just put it through a Manzel force-feed lubricator and any oil drop knows where it's going and how to get there fast. Manzel lubricators deliver just the right amount of oil to bearings, cylinders and packings. They start, stop, speed up and slow down in perfect synchronization with your machinery...unaffected by high steam, gas or air pressure Whatever your field, there's a Manzel lubricator to meet your needs. For our catalog, write Manzel, 256 Babcock Street, Buffalo 10, New York. Whatever your lubricating problem, you get the right answer if you



ask the man from

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

Happenings . . .

mark the first time that educational mass-flow gas-measurement equipment has been exhibited.

A Bright Future Seen for Butadiene-Base Rocket Fuel

A new butadiene-base rocket propellant has better capabilities than the current polyurethane propellants, according to North American Aviation Corp.'s Rocketdyne Division. A senior analysis engineer from the company, James E. Medford, said that studies have shown butadiene propellants have greater resistance to tear and strain, better case-bonding capabilities, and less tendency to slump than polyurethane. Butadiene propellants assure the feasibility of manufacturing solid-fuel rocket motors with a two-million-pound thrust, according to Medford.

Special Process 'Language' Developed by Socony Mobil

A new "process language" for computers has been developed by Socony Mobil Co. It converts the specialized vocabulary of refinery development engineers into one that can be used by the company's computer. The system enables engineers to give a problem to a computer after only a few days' training, with the computer itself performing vast amounts of translation, says Mobil.

1959 U.S. Exports Down, Says Bureau of Census

U.S. exports of crude oil and products declined in 1959 to 208,000 bpd, from 242,000 in 1958, according to Bureau of Census statistics. Exports averaged 189,000 bpd for the fourth quarter of 1959, compared with 197,000 for the third quarter, and 241,000 for the fourth quarter of 1958. Exports in December rose to 211,000 bpd from 149,000 in November and 192,000 in December 1958.

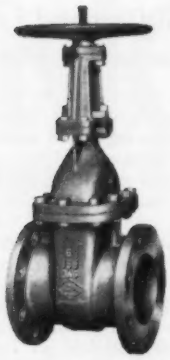
Crude and Product Imports Increase 45,000 bpd in '59

Crude oil and petroleum-product imports into the United States rose slightly in 1959 to 1.77 million bpd from 1.72 million in 1958, according to Bureau of Census statistics. Total imports for the fourth quarter of 1959 increased to 1.76 million bpd from 1.47 million in the third quarter. December 1959 imports went to 1.98 million bpd from 1.72 million in November.

U.S. Public Health Service Up With Antismog Device

A new device that "significantly reduces" pollution from auto exhausts but doesn't solve the problem of auto pollution in large metropolitan areas, has been announced by the U.S. Public Health

For more data on advertised products, use Readers' Service Cards, last page.



In this **Split Wedge Gate**

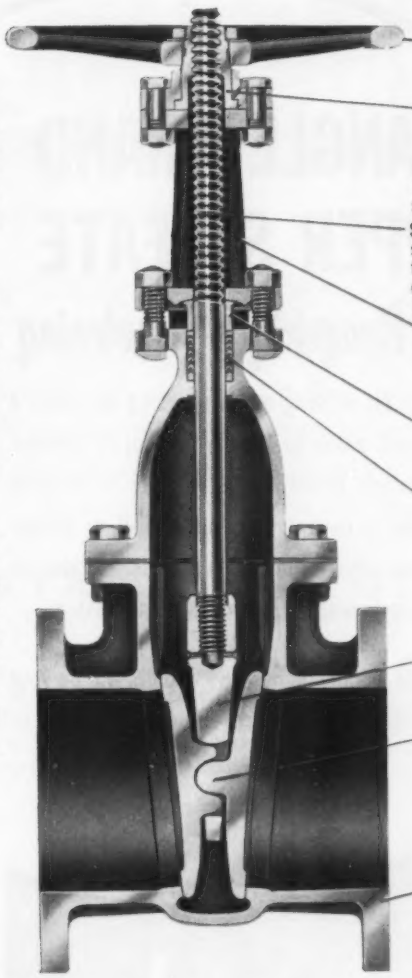
you can see why it pays to

Specify JENKINS for STAINLESS STEEL Valves, too

This picture shows the many points of excellence in the design and construction of Jenkins Fig. 1327 Split Wedge Stainless Steel Gate Valves. Compare them with any valve you know. You'll conclude that it's hard to beat Jenkins at making valves, no matter what the material.

But no picture can show the quality of the castings . . . the precision machining . . . the rigid inspection and testing that have gone into this valve. All of these are as important as design and metal alloys in assuring long, dependable, economical valve service. And, all of them are up to the peak standards for which Jenkins has been known for almost a century.

SEND FOR NEW CATALOG of Jenkins Stainless Steel Valves. You'll find in it the patterns you want, in a choice of alloys that satisfy the requirements of practically all corrosive services. Also, you'll see that these Jenkins valves meet valve industry specifications and the high standards established by the leading users of stainless steel valves. Jenkins Bros., 100 Park Avenue, New York 17.



WHEEL of high strength malleable iron designed for firm grip and easy operation.

YOKE BUSHING, easily renewable. Made of bronze, for ideal thread engagement with stainless steel spindle, to prevent seizing or galling of spindle threads. Bushing of stainless steel is optional.

SPINDLE has long thread bearing surfaces with correct lead for easy, tight closing. Screws into wedge carrier, then secured by a stainless steel pin.

YOKE BONNET has liberal space between yoke arms for easy access to packing box. Precision machined flange face assures uniform contact with gasket for a tight body-bonnet joint.

GLAND consists of two pieces — gland flange and gland follower — eliminates binding of follower in case gland bolts are tightened unevenly.

PACKING of Chevron-type Teflon in large packing box prevents leakage. Only a minimum load is required on gland, extending service life of packing.

WEDGE CARRIER connects wedge to spindle and raises or lowers it. Husky in size to stand any operating strains.

SPLIT WEDGE is the ball-and-socket design which automatically adjusts to the tapered seating surfaces for positive shutoff. The discs, revolving freely in the wedge carrier, produce a self-cleaning action on seating surfaces and reduce possibility of galling and seizing.

BODY —Through-port design for full, free flow. Ample wall thickness and good design provide extra strength to withstand stresses. End flanges conform to M.S.S. specs.

JENKINS

LOOK FOR THE JENKINS DIAMOND

VALVES

Sold Through Leading Distributors Everywhere

JENKINS BROS., 100 Park Avenue, New York 17, N. Y.

☐ Send the new stainless steel valve catalog

☐ Have a representative call on me

NAME & TITLE.....

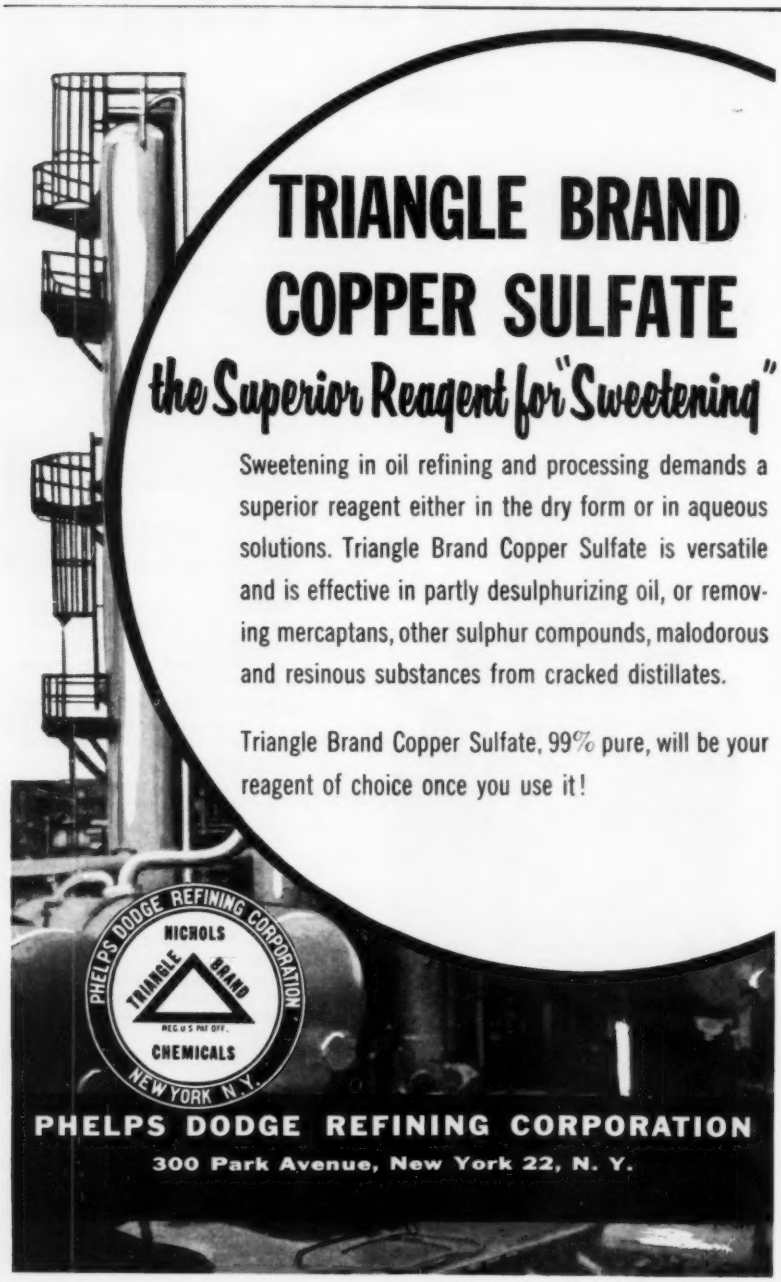
COMPANY.....

ADDRESS.....

Happenings . . .

Service. The assistant research and development chief for the PHS Engineering Division, Vernon G. MacKenzie, said that preliminary evaluation was based on tests of 20 cars of different make, condition and age. The device will be installed on all new cars sold in California not later than the start of the 1961-model year, according to the Automobile Manufacturers Association.

The devices takes a mixture of air and raw gasoline that normally escapes past piston rings and into the crankcase—then out through the breather pipe, and returns it to the engine to be burned. The mixture is primarily composed of hydrocarbons. While recognizing significance of the device, PHS officials said it "isn't likely" to have an effect on suspected cancer-producing hydrocarbons, doesn't destroy combustion-created olefins, and won't diminish hydrocarbons or carbon monoxide emitted by evaporation from the fuel system. However, the device destroys lead that is believed more toxic than lead compounds created in combustion. One Congressman, Rep. Roberts (D-Ala.) has recommended to the House that the device be used as a standard feature on all 1961 car models. Roberts is chairman of House Commerce Subcommittee on health and safety that handles air pollution legislation.


TRIANGLE BRAND
COPPER SULFATE
the Superior Reagent for "Sweetening"
Sweetening in oil refining and processing demands a superior reagent either in the dry form or in aqueous solutions. Triangle Brand Copper Sulfate is versatile and is effective in partly desulphurizing oil, or removing mercaptans, other sulphur compounds, malodorous and resinous substances from cracked distillates.
Triangle Brand Copper Sulfate, 99% pure, will be your reagent of choice once you use it!
PHELPS DODGE REFINING CORPORATION
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300 Park Avenue, New York 22, N. Y.

Crude-Oil Demand Forecast By the Bureau of Mines

Domestic crude oil to be exported or consumed in the United States during March has been estimated at 6.9 million bpd by the Bureau of Mines, compared with 7.5 million predicted for February. The forecast includes a gasoline yield of 44.4 percent, crude runs of 7.8 million bpd, and total gasoline demand 4.03 million bpd. December had total crude runs of 8.1 million bpd, including 960,000 bpd of foreign oil. Crude runs to stills during January were about 8.27 million bpd, including 936,000 bpd of foreign oil. Domestic-crude indicated demand for January was 7.3 million bpd. Stocks of distillate fuel at the end of January were nearly 28 million barrels higher than a year ago.

Freedom Foundation Awards Are Presented to API

Separate Freedom Foundation awards have been announced for the API. The institute was designated to receive the George Washington Honor Medal for helping to create "a better understanding of our great fundamental American traditions in their application to the everyday lives of citizens of our Republic." The award was made on the basis of materials prepared and disseminated by the institute last year on the occasion of U.S. oil's 100th anniversary. The actual presentation will be made in New York this spring. API secretary Willard M. Wilson is to receive the honor medal for an address on civic responsibility he delivered last May to the high school graduating class in his native Holdrege, Neb.

Technical Writers Meeting To Be Held June 13-17

Technical writers can expect some top-notch material at the eighth annual Technical Writers' Institute for writers in industry, the sciences and government. The meet will be held at Rensselaer Polytechnic Institute, Troy, N. Y., June 13-17. Included at the institute will be a practical writing laboratory, lectures by leading industrial writers, discussion groups in informal session, and personal conferences. Each person attending will receive a notebook containing a record of the week's work.

Noise Study in Progress By Esso R & E Staff

A study of refinery noise reduction is in progress by Esso Research and Engineering Co. The company is using tape recordings of furnace-burner operations to pinpoint noise sources and develop remedies such as improved mufflers or design changes. Esso hopes to cut noise level from its present 100 decibels to 85 or 90.

For more data on advertised products, use Readers' Service Cards, last page.

KNOWLEDGE STUDY CREATIVE URGE PROFESSIONAL DEDICATION

produce engineering achievement and accomplishment

Behind the design and manufacturing of Western Heat Exchangers lies the "creative urge" which invariably precedes productive accomplishment in any field of engineering. It is the initiative and creativity of Western's engineering personnel, combined with continuing research into the depths of thermal, mechanical and metallurgical design, that are largely responsible for the universal acceptance of Western heat transfer equipment throughout industry.

Western's engineers await your invitation to collaborate with your own engineers, toward the solution of your next heat transfer problem, however intricate.

WESTERN'S STAKE IN YOUR FUTURE

Your engineers, like ours, must *grow* in their profession, and to encourage their future development, Western is currently publishing a series of messages, as shown at right, in major trade journals. A more complete treatment of each subject is available in pamphlet form, either singly or in quantities, merely upon request. Write today.

One of a series appearing in OIL & GAS JOURNAL, CHEMICAL ENGINEERING, PETROLEUM REFINER, REFINING ENGINEER, CHEMICAL ENGINEERING PROGRESS.

serving the growth of the process industry

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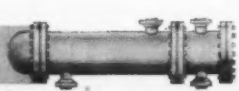
HEAT EXCHANGERS



WESTERN SUPPLY COMPANY

P. O. Box 1888 – Tulsa, Oklahoma

Personal, professional advancement demands thorough engineering knowledge, disciplined habits, creative thinking, constant application

"Intellectual let-down" — that tendency so common to many engineers to "stop learning" as soon as they acquire a sheepskin — will be completely out of style by 1999. Indeed, it is passe in today's accelerated engineering profession, because to stop learning is to stop growing:

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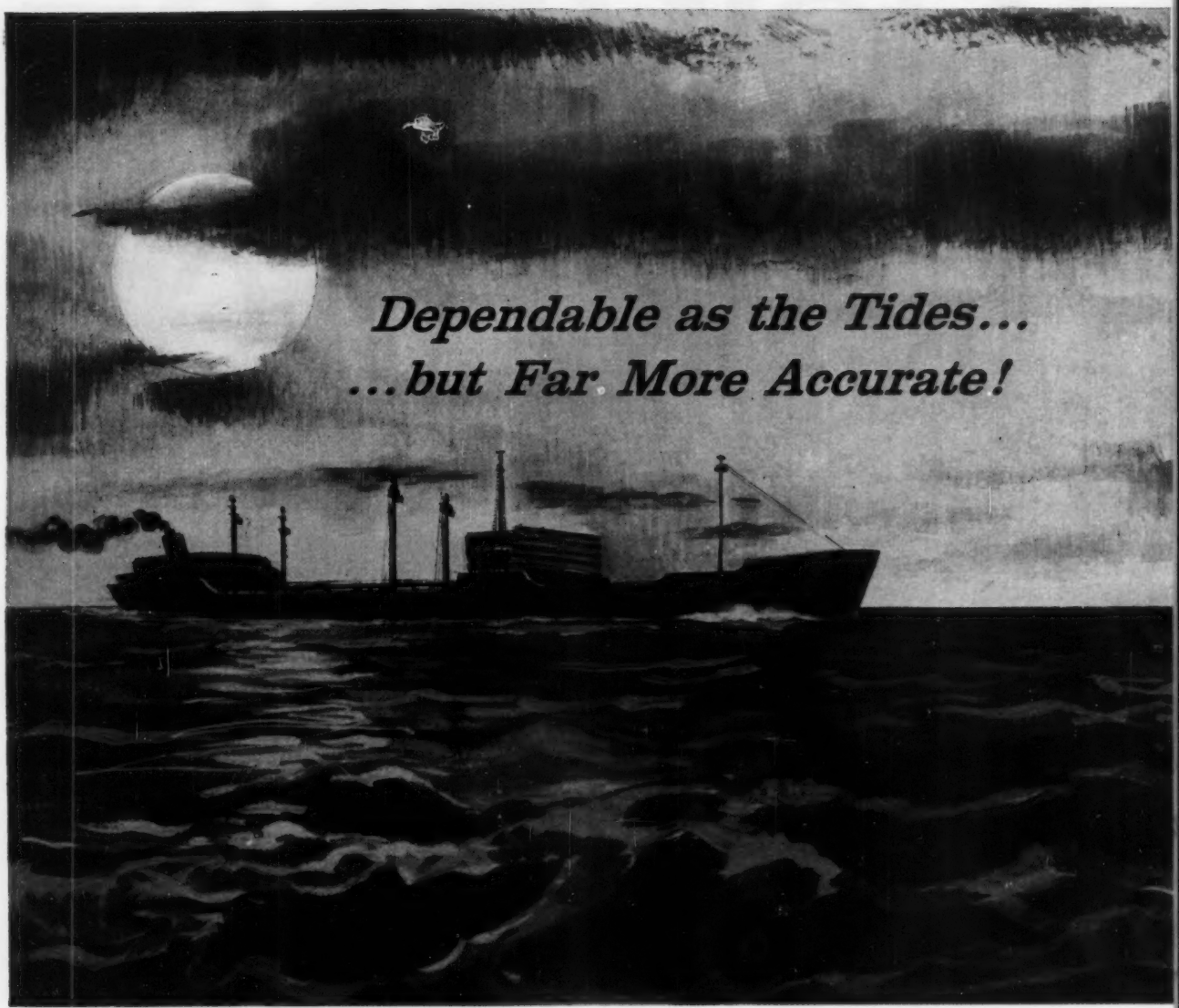

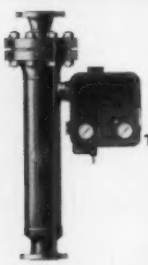

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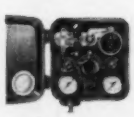

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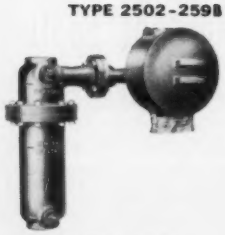


TYPE 2300-249

Wherever Industry Requires

FISHER PROVIDES 3 BASIC LEVEL-TROLS

Fisher Level-Trols operate on the displacement float principle. This, in conjunction with a torsional spring or "torque tube" transmits level changes to the pilot, and provides the simplest and most effective means yet discovered for accurately and continuously measuring liquid level or specific gravity.

The basic simplicity of the design makes the operation of these controllers virtually friction free and accounts for the great popularity they have achieved throughout the industrial world; particularly in the process and power industries.

Dependable Liquid Level Control

THE POPULAR TYPE 2500 PROPORTIONAL CONTROLLER

A compact and economical liquid level controller, the Type 2500, provides a proportional band adjustment up to 100%. It is pneumatically operated and level position is manually adjustable for quick and simple selection of set point. The 2500 is suitable for 3 to 15 psi or 6 to 30 psi output ranges and the action of the controller can be easily reversed in the field. It mounts on all standard Fisher Level-Trol float cages.

TYPE 2502 PROPORTIONAL CONTROLLER WITH RESET

This controller is the most complete single unit liquid level controller available today. It includes, in the same size case, all the features of the Type 2500, plus reset action. It therefore, automatically, brings the set point back to its original position and assures absolutely stable control. Reset rate is adjustable from .005 to 1 minute per repeat.

TYPE 2300 ELECTRONIC LEVEL-TROL

Explosion-proof design and external adjustments for proportional band and liquid level set point, make the Fisher Electronic Level-Trol ideal for use in hazardous locations. Available for output DC signals 1 to 5 ma, 4 to 20 ma or 10 to 50 ma. Has plug-in converter with printed circuit.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD ... CHANCES ARE IT'S CONTROLLED BY ...

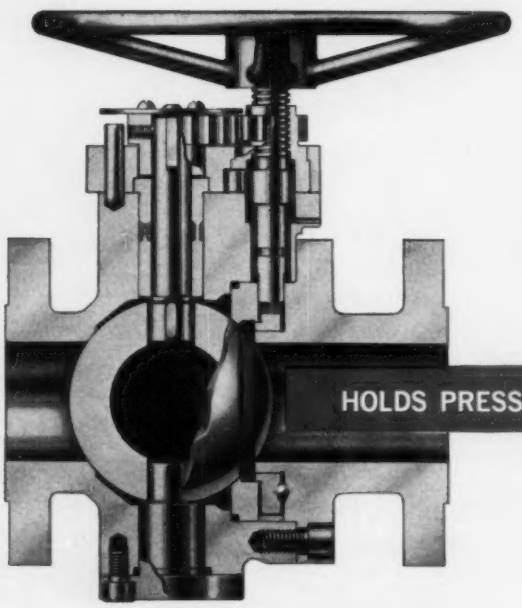
FISHER GOVERNOR COMPANY

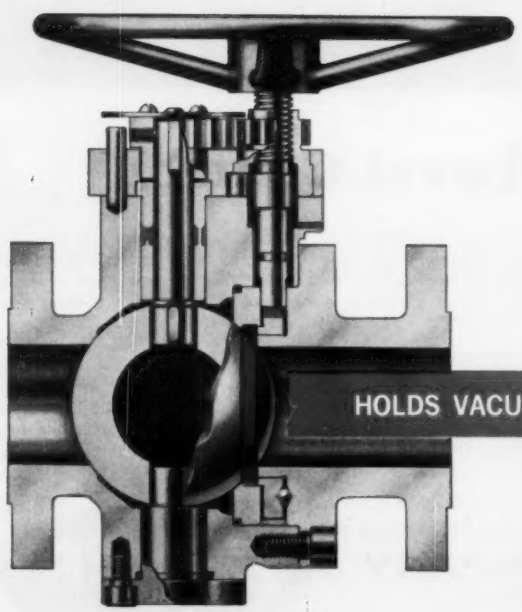
Marshalltown, Iowa / Woodstock, Ontario / Rochester, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIP. CO., CORAOPOLIS, PA.

FISHER® Controls

Exclusive Controlled Compressible Port Seal provides fast, positive shutoff in any service...





HYDRIL BALL Type "K" PLUG VALVES

Controlled sealing . . . a new concept in valve design . . . is the secret of Hydril's tight, bubble-proof shutoff. Hydril Ball-Plug Valves always seal positively against pressure from either direction—or against vacuum—because the fully confined packing ring is mechanically compressed between plug and seat when the valve is closed. This tightly compressed gasket type seal easily bridges clearances between parts as well as surface imperfections. Result: seal efficiency is unimpaired by prolonged hard usage, by rust or sediment.

Design of Hydril Type "K" Ball Plug Valves assures minimum maintenance costs. Non-lubricated, they employ no sealing lubricants. There's no sliding friction between plug and body to produce wear and abrasion.

The spherical plug is mounted on accurately positioned bearings, maintaining a minimal controlled clearance between plug and body. This contributes to easy, free-turning operation as well as to long service life.

●

Hydril valves are available in a wide range of sizes and ratings. Worm-gear and motor-operated models can be supplied. Get the full story on Hydril Valves from your nearby representative . . . or write Hydril Company for free Catalog No. V-60.

HYDRIL COMPANY

714 West Olympic Boulevard, Los Angeles 15, Calif.

Factories at: Los Angeles; Houston, Texas; Rochester, Pa.
Sales Offices: California: Bakersfield, Los Angeles, Ventura • **Louisiana:** Harvey, New Iberia, Shreveport **Oklahoma:** Oklahoma City, Tulsa • **Texas:** Corpus Christi, Dallas, Houston, Midland, Odessa • **Wyoming:** Casper **New York:** New York • **Canada:** Calgary, Edmonton

— Changing Times —

Gulf Oil Corp. has pulled out of Cuba after spending $7 million on geological, geophysical and drilling **over 14-year period.** Reason given—"harrassing moves by the Castro Revolutionary Government."

Shell Oil Co. of Canada has purchased $37 million worth of North Star Oil for majority control. **Acquisition included two refineries** and other facilities.

On aid-to-education scene, Frank Haskell, former Tidewater director who died in 1958, has left **$100,000 to Allegheny College for scholarships; Lehigh University received $6,200 grant** from National Science Foundation for support of basic research in thermodynamics of mixed gases; **children of Dow Chemical employees will get a shot at $1,500 college scholarship** under National Merit Scholarship program—based on competitive exams; **Du Pont has awarded $1.3 million in grants to 143 colleges,** for fundamental research and science education.

W. R. Grace & Co. has purchased 51-percent control of Cosden Petroleum Co. stock. Deal involved 1.58 million shares at $25 each.

Rohm & Haas Co. has bought idle butadiene plant at Louisville, Ky., from U.S. government for $6 million. Company will use 139-acre site to build new plant for other products—but won't make butadiene. No mention of what will be done with butadiene equipment.

Phillips Petroleum has purchased and assumed operation of **Tunstill gasoline plant, near Orla, Texas,** 40 miles Northwest of Pecos.

Gulf States Oil of Canada, subsidiary of Western Natural Gas, **has changed name to Western Natural Gas Co., Inc.**

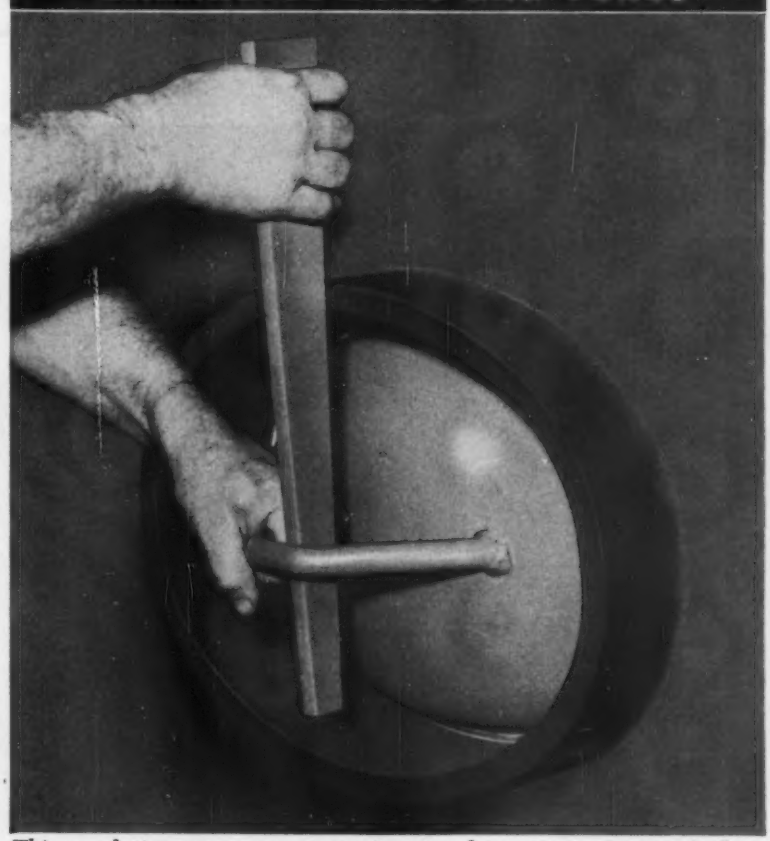
National Petroleum Council has set up Committee on Proven Crude Oil Reserves to prepare report of proven crude reserves in United States by years, through 1954. **It will arrive at estimate of reserves as of last December 31 as a base,** and credit such reserves back to year of discovery.

DX Sunray Oil has cut crude runs at its two Oklahoma refineries **by 5,000 bpd —on top of 7,500 bpd** cut in January. Combined cuts average 14 percent.

British American Oil's East refinery, Montreal,, has completed a million man-hours—almost a year's work—**without a lost time injury. Each employe received extra day's pay** for safety achievement.

House has passed bill authorizing Interior Department to contract for coal research projects to find new uses for the fuel. First year of program calls for $2 million to be spent.

NEW LENAPE WEDGE MANWAY*
Eliminates Bolts and Yokes



This revolutionary, new manway is not only easier to open and close, but is actually more economical than conventional bolted covers. Noted for its simplicity, the Lenape Wedge Manway assembly is a unique combination of only three metal parts—ring, cover and key wedge, plus a standard gasket, and is supplied as a "package" assembly.

FAST, SIMPLE OPERATION—As illustrated, to close the manway you insert the key wedge under the cover handle and over the opposite ring wall. Then, merely tap the wedge gently with a hammer until a tight seal is secured. That's all there is to it. Troublesome bolts and yokes are completely eliminated. Uniform gasket loading is assured.

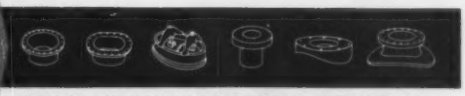
To open, you just tap out the wedge and remove the cover—all in a matter of seconds.

Write today for full details and prices on the amazing new Wedge Manway Assembly—another Lenape exclusive.

**Patent pending*

See our standard line of pressure vessel connections on pages 438-439 in the 1960 Chemical Engineering Catalog.

LENAPE PRESSURE VESSEL CONNECTIONS



LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 106 WEST CHESTER, PA.
RED MAN PRODUCTS

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It's Foxboro Consotrols

PHOTOGRAPHY BY ROBERT A. PACKO, TOLEDO

†Completely integrated Sohio Toledo unit has a refining capacity of 60,000 bbls. per day. The 13-acre facility requires only 17 operators per shift—was designed and built by the M. W. Kellogg Company.

for SOHIO

Reliable instrument performance a "must" at fully-integrated Toledo Refinery

Crude in at one end — finished product out the other—one continuous operation. That's the process flow at Standard Oil of Ohio's new 60,000 bbl. Toledo Refinery.

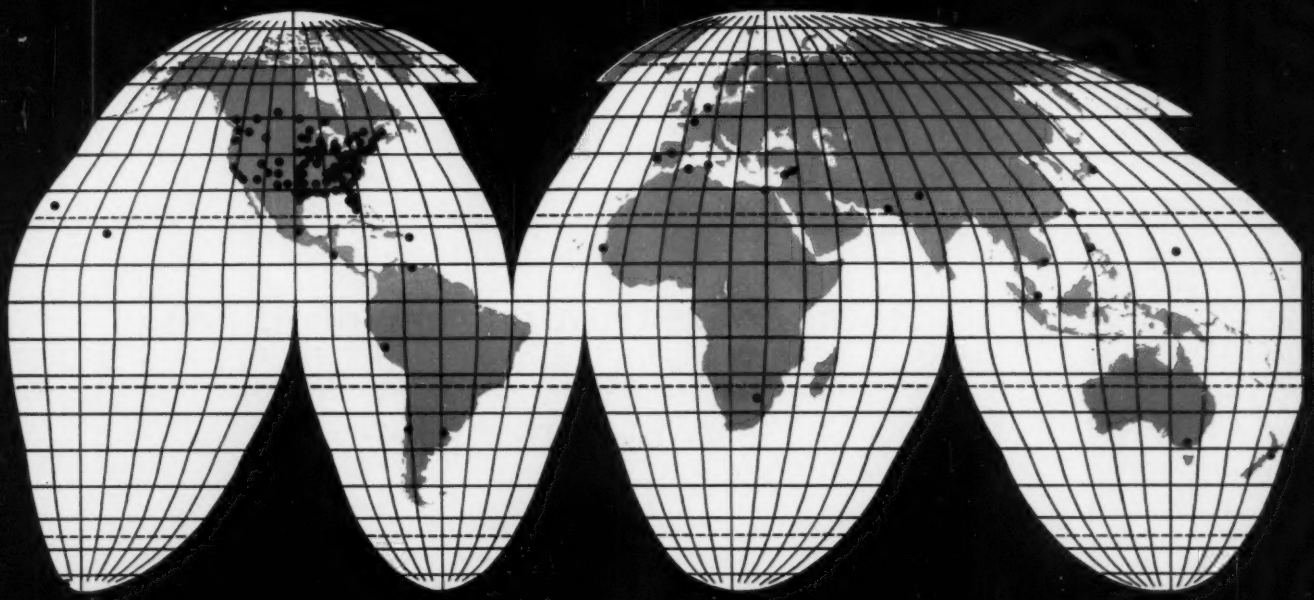
Since intermediate tankage has been eliminated, reliance on instruments approaches 100%. If one unit stops, the whole plant must stop — integration is that complete.

You'll find Foxboro Consotrol* instrumentation on every phase of this bold, cost-cutting refinery design. Accurate, dependable, low-maintenance Consotrols — pneumatic and electronic. The same "reliables" serving refineries the world-over.

If you're not already familiar with the Consotrol story ask your nearby Foxboro field engineer for full details. Or write Foxboro for Bulletin 13-18. The Foxboro Company, 743 Neponset Avenue, Foxboro, Massachusetts. *Reg. U.S. Pat. Off.*

FOXBORO
REG. U.S. PAT. OFF.

↓Nerve center at Toledo is this 96-ft. Foxboro-instrumented control panel. Six "satellite" panels handle local control. Since unit must work as one continuous operation—or not at all—reliable instrument performance is essential.



There's a world of service available

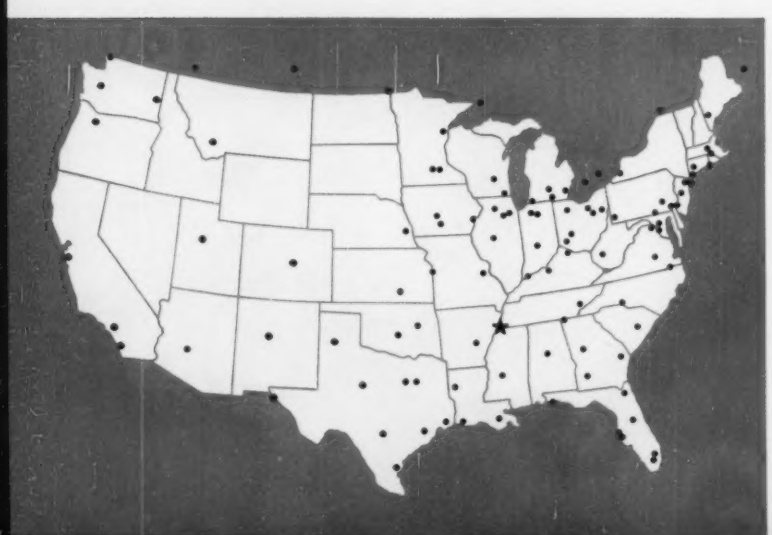
when you specify *LAYNE*

PUMPS • WATER WELLS • WATER TREATMENT

Any service is only as good as its availability when you need it.

Layne service for *any* pumps, wells, water systems and water treatment for Industry—Municipalities—Agriculture is available throughout the world, 24 hours a day. The vast network of Layne Associate Companies with over 75 years' experience, trained personnel and quality Layne replacement parts, assure prompt and complete service wherever you may be located. Industrial Sales Representatives in major cities. Write for Layne Service Bulletin 100.

Layne complete water services include: initial surveys • explorations • recommendations • site selection • foundation and soil sampling • well drilling • well casing and screen • pump design, manufacture and installation • construction of water systems • maintenance and service • chemical treatment of water wells • water treatment • all backed by Layne Research.



Layne SINCE 1882 — WORLD'S LARGEST WATER DEVELOPERS

LAYNE & BOWLER, INC., MEMPHIS

GENERAL OFFICES AND FACTORY, MEMPHIS 8, TENN.

LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD

Sales Representatives in Major Cities

ASSOCIATE COMPANIES

LAYNE-ARKANSAS COMPANY
Stuttgart, Arkansas

LAYNE-ATLANTIC COMPANY
Savannah, Georgia; Norfolk, Virginia; Glen Burnie, Maryland; Orlando, Florida; Albany, Georgia; Florence, South Carolina

LAYNE-CENTRAL COMPANY
Memphis, Tennessee; Pensacola, Florida; Jackson, Mississippi

GENERAL FILTER COMPANY
(Complete Water Treatment) Ames, Iowa

LAYNE-LOUISIANA COMPANY
Lake Charles, Louisiana

LAYNE-MINNESOTA COMPANY
Minneapolis, Minnesota

LAYNE-NEW YORK COMPANY
Linden, New Jersey; New Hyde Park, L. I., New York; Arlington, Massachusetts; Pittsburgh, Pennsylvania; Camden, New Jersey

LAYNE-NORTHERN COMPANY
Mishawaka, Indiana; Indianapolis, Indiana; Lansing, Michigan

LAYNE-NORTHWEST COMPANY
Milwaukee, Wisconsin

THE LAYNE OHIO COMPANY—Columbus, Ohio

LAYNE TEXAS COMPANY
Houston, Texas; Dallas, Texas; El Paso, Texas; Corpus Christi, Texas

LAYNE-WESTERN COMPANY
Kansas City, Missouri; St. Louis, Missouri; Aurora, Illinois; Ames, Iowa; Omaha, Nebraska; Wichita, Kansas; Denver, Colorado

INTERNATIONAL WATER SUPPLY, LTD.
London, Ont., Canada; Montreal, Quebec, Canada; Oakville, Ont., Canada; Vancouver, B. C., Canada; Saskatoon, Sask., Canada

INTERNATIONAL WATER CORPORATION
Pittsburgh, Pennsylvania

LAYNE PACIFIC DIVISION
Seattle, Washington

LAYNE-VENEZUELA C. A.
Caracas, Venezuela; Maracaibo, Venezuela

COMPANIA ARGENTINA PRODUCTORA DE AGUA, S.R.L.
Buenos Aires, Argentina

LAYNE FRANCE—Paris, France

LAYNE WELLS INTERNATIONAL
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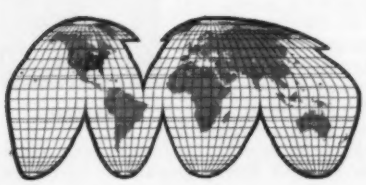

Meetings Calendar

March	
18	**Natural Gasoline Association of America,** Oklahoma Regional Meeting, Biltmore Hotel, Oklahoma City.
28–30	**Western Petroleum Refiners Association,** Annual Meeting, Hilton Hotel, San Antonio.
29	**American Institute of Chemical Engineers,** Separation Processes Meeting, Philadelphia-Wilmington Section, University Museum, University of Pennsylvania.
29–31	**American Power Conference,** Annual Meeting, Sherman Hotel, Chicago.
April	
5– 7	**Instrument Society of America,** National Chemical and Petroleum Instrumentation Symposium, Rochester, N.Y.
12–13	**Petroleum Industry Electrical Association,** Conference and Exhibition, Municipal Auditorium, Muehlebach Hotel, Kansas City, Mo.
19–21	**Southwestern Gas Measurement Short Course,** Drill Hall, North Campus, University of Oklahoma.
20–22	**National Petroleum Association,** Semiannual Meeting, Hotel Cleveland, Cleveland.
20–22	**Texas A. & M. Symposium,** Instrumentation for the Process, College Station, Texas.
21–22	**American Society of Mechanical Engineers-SAM,** Management Conference, Statler Hilton Hotel, New York.
25–26	**ASME,** Maintenance and Plant Engineering Conference, Chase-Park Plaza, St. Louis.
25–29	**American Welding Society,** Annual Meeting and Welding Exposition, Los Angeles.
27–29	**NGAA,** Annual Convention, Rice Hotel, Houston.
May	
2– 6	**American Petroleum Institute,** Midyear Meeting, Safety and Fire Protection Committees, Atlanta-Biltmore Hotel, Atlanta.
9–11	**ISA,** Power Instrumentation Symposium, San Francisco.
9–12	**API,** Midyear Meeting, Division of Refining, Statler and Sheraton-Cadillac Hotels, Detroit.
9–13	**American Society for Metals,** Southwestern Metal Congress and Exposition, Sheraton and Other Hotels, Dallas.
22–26	**ASME,** Oil and Gas Power Conference and Exhibit, Muehlebach Hotel, Kansas City, Mo.
23–26	**Design Engineering Show,** New York Coliseum.
June	
5–10	**ASME,** Semi-Annual Meeting and Aviation Conference, Statler Hilton Hotel, Dallas.
5–10	**Society of Automotive Engineers,** Summer Meetings, Edgewater Beach Hotel, Chicago.
13–15	**American Association of Cost Engineers,** National Meeting, Rice Hotel, Houston.
15–16	**WPRA,** Mid-Continent Regional Technical-Industrial Relations Meeting, Hotel Lassen, Wichita, Kan.
19–22	**AIChE,** Meeting, Del Prado Hotel, Mexico City.
26-Jul 1	**American Society for Testing Materials,** Annual Meeting and Apparatus Exhibit, Chalfonte-Haddon Hall, Atlantic City.
Aug.	
15–17	**ASME-AIChE,** Heat Transfer Conference and Exhibit, Statler Hilton Hotel, Buffalo, N.Y.
Sept.	
14–16	**National Petroleum Association,** Annual Meeting, Hotel Traymore, Atlantic City.
15–16	**ASME,** Engineering Management Conference, Hotel Morrison, Chicago.
18–21	**ASME,** Petroleum Mechanical Engineering Conference, Jung Hotel, New Orleans.
21–23	**ASME-AIEE,** Power Conference, Bellvue-Stratford Hotel, Philadelphia.
25–28	**AIChE** Meeting, Mayo Hotel, Tulsa.
25–28	**American Institute of Electrical Engineers,** Electrical Conference of the Petroleum Industry, Hotel Skirvin, Oklahoma City.
Oct.	
9–12	**ASME,** Rubber and Plastics Conference, Lawrence Hotel, Erie, Pa.
10–11	**ASME-AIEE,** Fuels Conference, Daniel Boone Hotel, Charleston. W. Va.
11–14	**National Association of Corrosion Engineers,** Northeast Region Conference, Prichard Hotel, Huntington, W. Va.
13–14	**California Natural Gasoline Association,** Fall Meeting, Hotel Miramar, Santa Monica, Calif.
25–28	**National Association of Corrosion Engineers,** South Central Region Conference, Mayo Hotel, Tulsa.
Nov.	
27–Dec. 2	**ASME,** Annual Meeting, Statler Hilton Hotel, New York.

Men In Industry...

Click

Barnes

Brunner C. Barnes and **Robert R. Click** have formed Barnes & Click, an engineering firm specializing in consultation and design work for natural gas production and processing. Offices are in the Rio Grande National Building, Dallas. Both men were formerly with Mobil Oil Co., Dallas. Barnes joined Magnolia Petroleum Co. in 1940, and since 1953 had been chief process design engineer in the Natural Gas Department. Click joined Magnolia in 1949 and had been the Natural Gas Department's senior operations control engineer.

Ewell E. Mitchell has been appointed plant manager of the Institute, W. Va. plant, Goodrich-Gulf Chemicals, Inc. He had been production manager of the Port Neches, Texas, plant since 1953. A 1932 graduate of Rice Institute where he received a degree in chemical engineering, Mitchell joined a major petroleum company after graduation. He joined the Port Neches plant staff in 1943 as a senior technical man and later filled various supervision assignments before becoming the plant's production manager.

Wheeler G. Lovell, director of automotive products development, Ethyl Corp., Detroit, has been elected chairman of the Division of Petroleum Chemistry, ACS, 1960. He succeeds **Dr. William E. Bradley,** manager of research, Union Oil Co., Brea, Calif. **Dr. Charles L. Thomas,** scientific advisor, Sun Oil Co., Marcus Hook, Pa., was chosen chairman-elect of the division. **Dr. Bernard M. Sturgis,** E. I. du Pont de Nemours & Co., Deepwater, N. J., and **Dr. Herbert J. Passino,** The M. W. Kellogg Co., New York, were re-elected secretary and treasurer, respectively.

Roe E. Withrow, Jr., formerly a member of the treasurer's staff, The Dow Chemical Co., has been appointed assistant to the president of Dow Chemical International, Ltd., S.A., a Dow subsidiary. He will procure and analyze data and reports from overseas production and international business activities. Withrow will also act as secretary of the Dow International Executive Committee, assistant secretary of the Dow International board and a member of the overseas finance committee.

Jack W. Roach has been named vice president of personnel for Kerr-McGee Oil Industries, Inc. His responsibilities include administration of the company's Industrial Relations Department and Employe Benefits Section. Roach previously handled staff assignments for the president in his position as vice president of Kerr-McGee. He joined the company in 1952 and held several managerial positions before becoming a vice president in 1955.

John C. Thomas has been named a laboratory assistant in the Colorado School of Mines Petroleum Refining Department. A chemical engineering graduate of Texas A & M College, he has been an instrument development engineer for Phillips Petroleumt Co. the past six years. He had previously been a chemical engineer for Phillips.

Hurd

Mandell

Leslie W. Hicks has been transferred from Texas City to American Oil Co.'s Yorktown, Va., refinery to become chief refinery engineer. **James F. Mandell** has become assistant director of engineering-construction replacing Hicks. **Paul J. Hurd** has been transferred from the Plant Engineering Department at Yorktown to the General Engineering Department at Texas City to become section head, process facilities.

Hicks

Hicks joined Amoco at Texas City as an apprentice engineer in 1948. He was promoted to senior engineer and transferred to Yorktown in February 1955—then returned to Texas City as assistant director of engineering-construction in March 1957. Mandell joined the company at Texas City in 1940. Starting as an instrumentman third class, he advanced through several classifications, becoming section head in general engineering in February, 1955. Hurd joined Amoco as an instrumentman third class in 1940. After serving in several jobs in the Engineering Department, he became project coordinator for construction of the new refinery at Yorktown. He was transferred to Yorktown in that same capacity in December 1955.

John F. Daley has retired as a vice president and member of the Executive Committee, E. I. du Pont de Nemours & Co., after a career of 45 years. He will remain a member of the board. **Colgate W. Darden, Jr.,** has been elected a member of the board to fill the vacancy created by the resignation of **Alfred P. Sloan, Jr.,** in November. Darden has been a member of Congress, Governor of Virginia, and most recently president of the University of Virginia.

Ralph M. Knight has been named president of The Rexall Drug and Chemical Co.'s new Chemical Division. He was formerly vice president and polyethylene manager of National Distillers and Chemical Corp. From 1939-52 he was with E. I. du Pont de Nemours & Co. as a process engineer and plant manager. Assisting Knight as vice president in charge of Chemical Division production will be **John R. Provo,** formerly division superintendent of polyethylene manufacture for Du Pont. Both men will locate in Los Angeles.

Robert K. Brooke has been named assistant to the president of the Independent Refiners Association of America. He will be a permanent full-time employe of the association, located at the Washington headquarters. Brooke will represent the IRAA president on a continuing basis before government agencies and Congress. He will be responsible for all association activities in Washington except those handled by its legal counsel. Before his appointment, Brooke had been with Asiatic Petroleum Corp. for 20 years.

Lt. Gen. Manuel J. Asensio (USAF Ret.) has joined Texas Butadiene & Chemical International, Ltd., as chief executive officer of the Argentine company Texas Butadiene is organizing. His headquarters will be in Buenos Aires. Gen. Asensio is a graduate of the United States Military Academy and earned a civil engineering degree at the University of California. During his 33 years in military service, Gen. Asensio spent 21 in the Corps of Engineers.

Ray Powell, superintendent of Texaco Inc.'s refinery at Lawrenceville, Ill., has been appointed assistant general manager of the Refining Department, Houston. **Frank D. Dorr,** assistant superintendent in charge of operations at the Lawrenceville works, will succeed Powell as superintendent. Other appointments at Lawrenceville are: **Harry R. Robinson,** assistant superintendent in charge of maintenance and construction, to succeed Dorr; **Donald N. Graham,**

Powell

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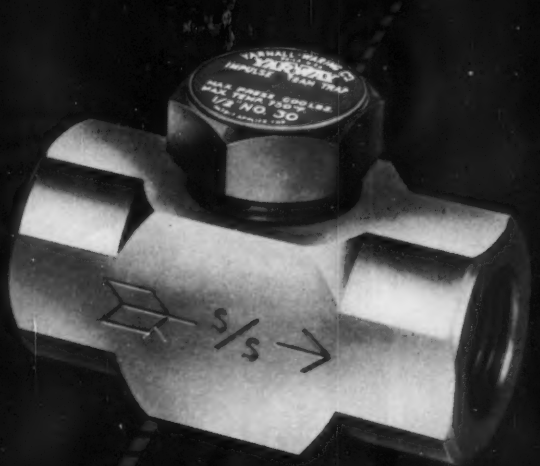

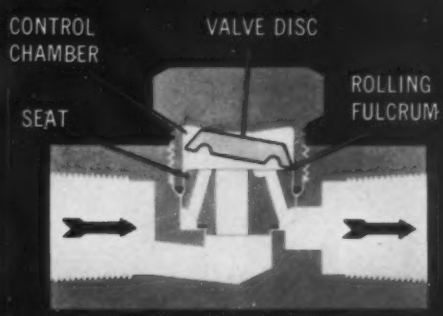

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Now, at no extra cost to you, this new Crouse-Hinds Prismatic Globe reduces troublesome glare while increasing "seeing" brightness. Provides more efficient working light, by softening and distributing the light evenly – without reducing the amount of usable light.

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Men . . .

supervisor of operations, to succeed Robinson; **Robert C. McCay,** chief process engineer, to succeed Graham; **W. Michael Neuman,** senior product engineer, Petrochemical Department, New York, to succeed McCay.

Dr. Howard L. Malakoff has been elected vice president and general manager of Cities Service Research and Development Co. Since 1956 he has been manager of the Development Department, Petroleum Chemicals, Inc. Dr. Malakoff joined Cities Service Oil Co. in 1943 as a chemical engineer. In 1945 he was named engineering section chief of that company's Chemical Research Division. In 1948 he joined Cities Service R & D as technical assistant to the director of Research, and in 1954 was appointed staff administrative assistant for Cities Service Petroleum Inc.

Malakoff

J. P. Herrin has been named chief engineer of Texas Petro Gas Co., which he joined in December. Holder of a B.S. degree in chemical engineering from Oklahoma State University, he had been with Sinclair Oil & Gas Co. for ten years before joining Texas Petro. His last assignment with Sinclair was as senior process engineer, Gas Products Department.

Henry J. Geremia has been appointed an engineering associate by Esso Research and Engineering Co. He is currently assigned to the Esso R & E European office in The Hague, Netherlands. He has been there since August 1959, as a member of the Construction Engineering Division's staff responsible for contractor engineering work.

Wayne Elledge, plant engineer at El Paso Natural Gas Products Co.'s Ciniza, N. M., refinery, has been promoted to chief project and mechanical engineer for the company. He will be replaced at the Ciniza refinery by **George Harrison,** chief inspector for the company. **Don Watzke** becomes chief inspector.

Porter Wharton, Jr., has joined Kerr-McGee Oil Industries, Inc., as director of public relations. For more than seven years he was with Miles Laboratories, Inc., Elkhart, Ind., in a similar capacity. Previously with *The Elkhart Truth* newspaper, Wharton is a graduate of Indiana University.

O. C. Johnson, formerly regional manufacturing manager for Mobil Oil Co., has been named manager of manufacturing operations. Following graduation from the University of Kansas in 1934, he joined the company's Augusta, Kan.,

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from .65 gph to 1624 gph

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Self-contained lubricating system—no down-time for lubrication. E.Z. Clean Cartridge liquid end simplifies maintenance. Simplex models pump up to 812 gph at a maximum pressure of 10,000 psi. Duplex models double that capacity.

American controlled capacity proportioning pumps have repetitive metering accuracy of plus or minus 1%, when operating between 10% and 100% of capacity. Feed precisely metered fluids or slurries in virtually all ratios, with flow, temperature, pressure, conductivity, pH and other controlled process variables.

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- nylon dust covers protect bearing surfaces
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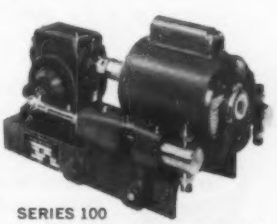

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Simplex models pump up to 13.10 gph at a maximum pressure of 1000 psi. Duplex models double that capacity.

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For more data on advertised products, use Readers' Service Cards, last page.

Men . . .

refinery as a laboratory chemist. He held technical and supervisory positions there until 1947 when he became operating superintendent of the East St. Louis, Ill., refinery. In 1952 he was made manager of the refinery. Johnson moved to the New York headquarters in 1956 as Central Region manager, and became regional manager of manufacturing in March 1959.

J. T. Robichaux has been appointed general superintendent of plants, New York Region, for American Oil Co. Formerly assistant manager of Amoco's Terminal Department, he succeeds **K. A. Beede,** deceased.

Bernard J. Gaffney of Wood Conservation Co., St. Paul, Minn., has been elected president of the American Association of Cost Engineers. Others elected were **Jay M. Gorey,** Esso Research and Engineering Co., Linden, N. J., vice president; **Thomas C. Ponder,** PETROLEUM REFINER Magazine, Gulf Publishing Co., Houston, secretary; and **Cecil H. Chilton,** McGraw-Hill Publishing Co., New York, treasurer.

Dr. Adolph I. Snow has been named director of the Radiation Division, Sinclair Research Laboratories, Inc. He has been conducting Sinclair's program relating to radio-active tracers, and the effects of radiation on petroleum products and processes.

William C. Ludi has been appointed an engineering associate by Esso Research and Engineering Co. A member of the firm's Construction Engineering Division at the Esso Research and Engineering Center, Florham Park, N. J., he has been with the company since 1937. During construction of the new center, Ludi was head of the Planning and Construction Section in charge of a 14-month building project.

Ernest W. Kirchheimer has been appointed senior process economist in the Development Department, Texas Butadiene & Chemical Corp., New York. He previously spent three years in TB & C's Channelview, Texas, plant as a process engineer. He was formerly with Texas City Chemicals, Inc., where he was process superintendent. Kirchheimer is a graduate of Texas A & M College.

William M. Cocke has been named vice president and general manager of Cit-Con Oil Corp. He has been assistant general manager of Cit-Con since 1950. Cocke first joined Cit-Con in 1947. He was previously with Marland Oil Co. and Continental Oil Co. He graduated from the University of Oklahoma with a B.A. degree in chemistry and once taught science at Ponca City, Okla., High School.

Stephen P. Cauley, formerly assistant manager of the Fuel Oil Division, Gasoline and Fuel Oil Department, has been appointed commercial pricing manager for Mobil Oil Co. A graduate of Rose Polytechnic Institute, he joined the company's East Chicago, Ill., refinery in 1936. He became supervisor of the Product Engineering Division, Technical Service Department, in 1943, and attained his most recent position in 1948.

Robert L. Minckler, senior vice president of Mobil Oil Co., plans to retire about the middle of the year. He was president of General Petroleum Corp. from 1948 until it merged with Mobil Oil Co. Minckler joined General Petroleum in 1924 and became assistant to the president ten years later. He was elected a director in 1941, a vice president in 1945, executive vice president in 1947 and president in 1948.

Fred L. Hartley, vice president of Union Oil Co. of Calif., has been elected a director and senior vice president. **Arthur C. Stewart,** director and senior vice president, who had supervised marketing operations, will be responsible for research. He also will be a director of Collier Carbon and Chemical Corp., a Union Oil subsidiary. **Dr. W. E. Bradley** has been named director of research succeeding Hartley.

J. M. Williams has been promoted to senior coordination technician, Coordination Division, at Humble Oil & Refining Co.'s Baytown, Texas, refinery. He prepares refinery fuel product forecasts and studies to optimize fuel operations. Williams has a B.E. degree in chemical engineering from Vanderbilt University.

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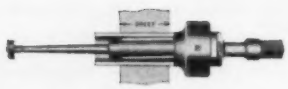

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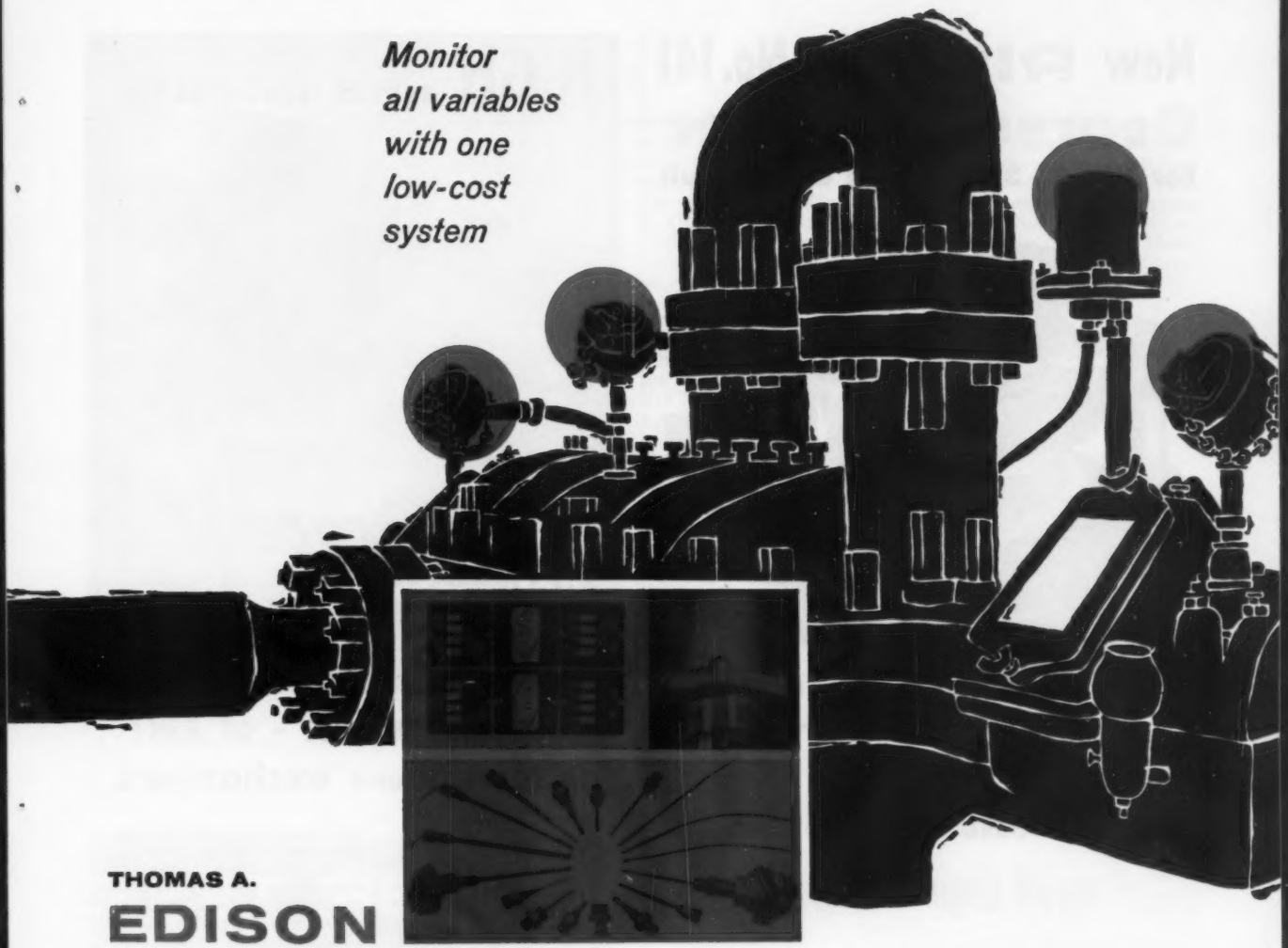

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omniguard system cuts operating and maintenance costs—
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Whatever your type of operation, manual, remote or automatic, you can reduce personnel, operating and maintenance costs with a low-cost Thomas A. Edison Omniguard monitoring system.

Virtually all critical temperatures and pressures can be guarded with this one system: motor and pump bearing temperatures, pump case temperatures, station suction and discharge pressures, unit suction and discharge temperatures and pressures, motor winding temperatures, and in compressor stations compressor cylinder temperatures, cooling water temperatures and lube oil temperatures and pressures.

In addition to guarding against equipment failure, Omniguard assures optimum use of your equipment. Due to its accurate monitoring you can operate your equipment at maximum load with complete safety. You'll be able to handle greater capacities with less equipment. Fuel and maintenance costs will be cut.

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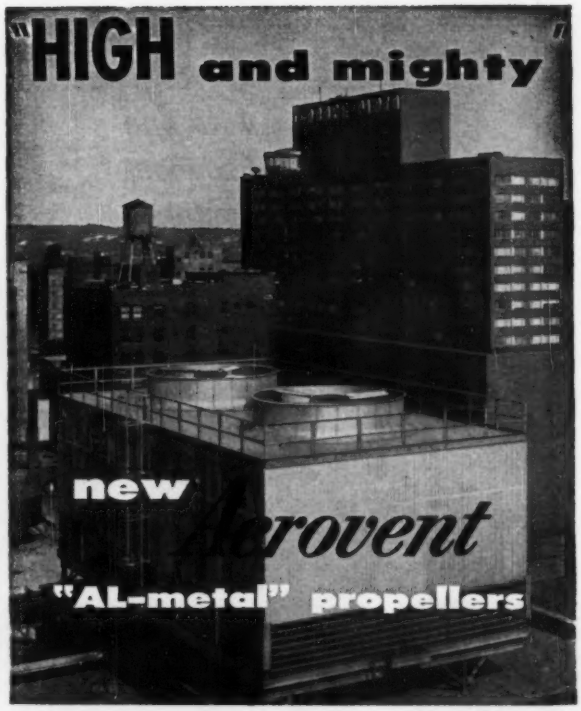

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in towers and exchangers

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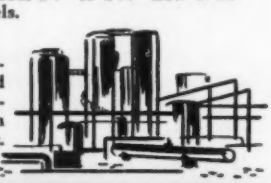

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Suppliers Notes...

SAN DIEGO EQUIPMENT & SUPPLY CO. has completed construction of a new warehouse and sales office in San Diego. Specializing in construction, drilling and rock excavation equipment, the newly formed firm represents the Gardner-Denver Co., Bay City Shovel Co., and the Rock Bit Division, Timken Roller Bearing Co.

ARMOUR INDUSTRIAL CHEMICAL CO. has named **Robert Strain** industry manager for polymer and surfactant chemicals. He joined Armour as a salesman in 1950 and has since been headquartered at Indianapolis. Strain will deal with the commercial development of industrial emulsifiers and specialized processing aids for rubber and other high polymers.

KEASBEY & MATTISON CO. has promoted **Robert S. Hartman** to manager, planning and inventory control, Ambler, Pa. He joined K&M in 1948 as a research chemist and most recently has been operations research supervisor.

VULCAN CONTAINERS INC.'s Eugene W. Gehm has been named sales manager. He will be responsible for the direction of Vulcan sales activities throughout the country. Gehm was previously assistant sales manager.

WEAR-EVER ALUMINUM, INC.'s A. B. Wilber, vice president of the company and manager of Aluminum Company of America's Process Development Laboratories since 1946, has retired after 40 years with Alcoa. A 1917 graduate of Allegheny College, Wilber joined Alcoa in 1919 as a chemist in the former Technical Direction Bureau.

THE BURGESS-MANNING CO.'s Industrial Silencer Division has appointed as new representatives, The Barth Engineering Co., 3871 Piedmont Ave., Oakland, Calif.; E. N. Murray Co., 518 Seventeenth St., Denver; Adams Engineering Sales, P. O. Box 888, Decatur, Ga., and Carlson-Rutledge Co., 4500 Euclid Ave., Cleveland.

DANIEL ORIFICE FITTING CO. has named **Victor M. Morgan** sales engineer, Houston office. He formerly worked for Celanese Chemical Corp., Walter Kidde Engineering Co., and Farnsworth & Chambers Construction Co. He attended the University of Hawaii.

JONES & LAUGHLIN SUPPLY DIVISION has named **R. E. Dame** salesman, Edmonton, Alta. A graduate of the company's sales and training program and holder of a bachelor of commerce degree from the University of Alberta, he has been with the company since 1958.

U.S. STEEL CORP.'s National Tube Division has named **Truman H. Kennedy** vice president of operations and **Robert E. Williams** vice president of sales. Kennedy succeeds **Edmund G. Price,** who has become executive vice president of the division, while Williams succeeds **Henry J. Wallace,** who has been named president of the division.

WILKENING MANUFACTURING CO., Philadelphia, has named **Leonard M. Cohen** treasurer. He has been assistant treasurer, for the past six years, and has been assistant secretary also, a post he retains.

FOSTORIA CORP.'s Chempump and Dynapump Divisions have a new sales office in Schenectady, N. Y., at 1629 Eastern Parkway. Under the direction of **Lee Health,** it will serve Western New York.

THE WALLING CO., Omaha, Neb., has been named a representative for Solar Aircraft Co.'s industrial bellows and expansion joints in Iowa, Nebraska, and South Dakota.

LABLINE, INC., manufacturer of laboratory instruments, apparatus and equipment, has been accepted by ACS to sponsor an annual award in the fields of chromatography and electrophoresis. The award will recognize outstanding contributions in these fields, with particular consideration given to development of new methods designed for accuracy and speed. It

TEST METERS
IN STAINLESS STEEL

Specially made for the measurement of small volumes of gases and with special applications in the Petroleum Industry. Robust and easily cleaned.

Type E.40 Wet Meter, 1/10 cu. ft. per rev., 40 cu. ft. per hour, OR alternatively 2½ litres per rev., 1000 litres per hour. Stainless Steel case and drum.

PARKINSON COWAN INDUSTRIAL PRODUCTS

(A Division of Parkinson Cowan Ltd)

PARKINSON COWAN INDUSTRIAL PRODUCTS

Dolphin Works, Fitzalan St.,
Kennington Road, London, S. E. 11. Tel. Reliance 2406

Babbitt *Adjustable* SPROCKET RIM *with Chain Guide*
CHANGES THAT DANGER ZONE TO A SAFETY ZONE

The distance between the floor of your plant and your overhead valves is a DANGER ZONE when piled up boxes or even ladders are used to reach the valves.
Turn it into a SAFETY ZONE — equip your overhead valves with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. If your supplier does not carry them, contact us direct.

Babbitt STEAM SPECIALTY CO.

6 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.

Suppliers . . .

will consist of $1,000 and a plaque, with travel allowances of $150 for the recipient, who is to receive the award at a meeting designated each year by the ACS. A Canvassing Committee has been appointed to select the winner of the first annual award in 1961.

HARCO LABORATORIES, INC. has named R. E. Surkamp Co., Cincinnati, to handle sales in Southern Ohio. Martin-Rettger, Inc., Cleveland, will cover Northern Ohio and Erie County, Pa. The J. Y. Schoonmaker Co., Dallas, will handle Oklahoma, Texas, Arkansas and Louisiana.

HORACE T. POTTS CO. has announced the following executive appointments: **Donald C. Taylor,** former manager, Baltimore warehouse, to assistant to the president, responsible for research and development; **John W. Reckard,** general sales manager, to vice president in charge of all company sales and manufacturing operations; **John A. Stringer,** company comptroller, to vice president responsible for financial and purchasing functions; **William C. Spencer, Jr.,** company secretary, to director of purchases; **George A. Parker, Jr.,** manager of stainless sales, to sales manager; **Horace T. Potts, III,** to manager, stainless sales, and **Edward R. Potts,** warehouse superintendent.

New handy refractory guide

Here are a few of the technical factors covered...

Abrasive qualities
Acid resistance
Coefficient of expansion
Composition
Compressive strength
Conductivity
Drying shrinkage
Fusion point
Modulus of rupture
Selling properties
Temperature limit

SEE OUR CATALOG IN REFINERY CATALOG OR SEND FOR A COPY

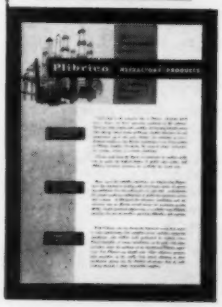
All the facts you need to select the right refractory for every operating condition in the refinery industry

Every physical and performance characteristic of refractories specially selected from Plibrico's complete line is charted for your quick reference.

You'll find grades of Plicast castable refractory with exactly the properties you need...the temperature range, the abrasion resistance, the insulation value. You'll also find select grades of the original plastic refractory, Plibrico Jointless Firebrick, for *any* operating condition.

See how Plibrico provides unified responsibility through complete service...including products, engineering and installation.

WRITE FOR FREE REFERENCE CHART #76 giving detailed data on products for refinery process linings or consult your local Plibrico Field Engineer for technical assistance.



9219

Plibrico REFRACTORIES

Serving the Furnaces of Industry 24 Hours a Day

PLIBRICO CO., 1809 Kingsbury, Chicago 14 • Canadian Plant: New Toronto, Ont.

Plibrico Sales and Service Throughout the World

REFRACTORY PRODUCTS • ENGINEERING • CONSTRUCTION

WORTHINGTON CORP. has named **W. C. Cheek, H. W. King** and **W. J. Van Vleck** commercial vice presidents. Cheek, a mechanical engineering graduate of North Carolina State College, joined Worthington in 1920. He was appointed manager, Chicago District sales office in 1945, then midwest regional sales manager in 1957. King, currently western regional sales manager, joined the company in 1923 after graduation from the University of California. He was successively a salesman in Kansas City and Seattle, then manager, San Francisco District sales office, 1949-52. Van Vleck, promoted from manager, New York District sales office to commercial vice president and eastern regional sales manager, joined the corporation in 1924. He was appointed manager of the Atlanta District sales office in 1944 and became New York District office manager in 1952.

TUBE TURN PLASTICS, INC. has elected **Earl A. Erich** vice president. A graduate of Muhlenberg College with a B.S. degree in chemistry, he began his career as a research chemist for Atlas Mineral Products Co. and later organized its Thermoplastics Division. Erich joined Tube Turns Plastics in 1955 as a specialist in solving piping corrosion problems and later headed sales programs on the West Coast and in the southwest. He became assistant sales manager in 1956 and sales manager the following year.

NORTON INTERNATIONAL, INC. has named **Dr. Wilfred F. L. Place** vice president and general manager succeeding **Frank M. Ryan,** retired. Dr. Place joined Durex Corp. in 1946, and was assistant to the company's president from 1946-48. He became managing director of Abrasifs Durex, Paris, France, in 1949. He was managing director of Behr-Manning de France for seven years before becoming a vice president of Norton International Inc. in charge of Behr-Manning products, in 1957.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has named **Carl Boyer, Jr.,** chief engineer, Rubicon Instruments Division, Philadelphia. He had been chief evaluation engineer for the company's Brown Instruments Division and was with the Rubicon Co. for a number of years before its acquisition by Honeywell. Boyer is a graduate of Drexel Institute of Technology and is an instructor in electrical engineering in its evening college.

BLAW-KNOX CO., Buflovak Equipment Division, Buffalo, N. Y., has appointed **E. L. Teller** sales engineer for gas equipment, with headquarters in the Buffalo office. Teller joined Blaw-Knox in 1956 as a Buflovak Division project engineer in the Gas Cleaner Department. He was promoted to principal engineer in the Gas Conditioning Department in 1958, the position he held until his recent appointment.

THE COOPER-BESSEMER CORP. has appointed **David James** a sales engineer,

DU PONT *Petroleum Chemicals* NEWS

Number 101 in a Series of Bulletins for the Petroleum Industry

MARCH-APRIL 1960

FOA-2 a money saver on many fronts

IN MARKETING

Worriers are good customers for service stations

Skilled psychological researchers, visiting service stations, querying customers and attendants, listening in to their questions and answers, found that motorists worry about *almost everything* concerning their cars . . . and, as you would expect, women worry about *everything.*

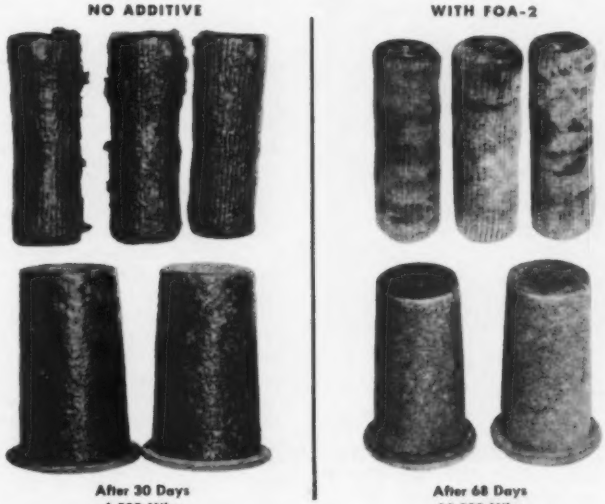
How to turn these worries into positive selling points is the subject of a series of four new folders DuPont makes available for your dealer meetings.

The four folders are concerned with those who worry about their tires, oil and oil changes, lube jobs, and lastly, the multiple worries of women. Each contains tips on how to put those worries to rest. The theory behind it all being that "If you save them worry . . . they'll save their business for you."

Refiners, large and small users, all enjoy savings

DuPont Fuel Oil Additive No. 2 provides a wide range of benefits for refiners, distributors and users. It ends the multiplying costs of sludge and gum formations which penalize everyone. Simple and economical to use, it is effective throughout the whole range of distillate fuels. Refiners have found the benefits of FOA-2 more than pay for the cost of addition.

FIGURE 10
FOA-2 RETARDS FILTER PLUGGING IN DIESEL LOCOMOTIVES



In the refinery

FOA-2 added to catalytic cracked fuel oils produces a stable product, at a fraction of the cost of other means.

It can be used to overcome incompatibility that may be encountered when blending catalytically-cracked and straight-run fuel oils.

Added to residual fuels *before* they go into storage, FOA-2 will reduce or prevent costly mechanical cleaning of storage facilities. The product may also be used gradually to disperse sludge which may already be present.

CONTINUED OTHER SIDE

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DUPONT *Petroleum Chemicals* NEWS

CONTINUED *FOA-2*

Fuel Oil Customers

It has been found that FOA-2 effects a major reduction in home heating service calls. It minimizes oil burner ignition failures . . . keeps the oil free-flowing and clean burning . . . ends sludge formation in tanks, filters and nozzles. Being a nonmetallic *ashless* additive, it does not leave ash deposits to foul operation of the stack controls or ignition system.

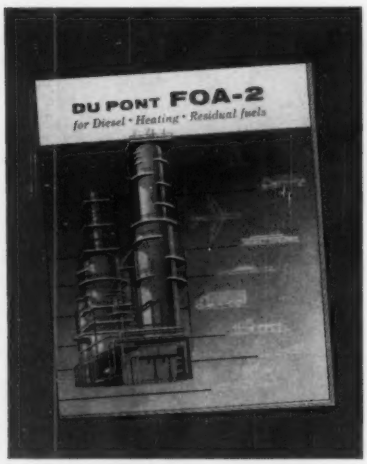
In storage, stocks accumulated during the summer remain satisfactory for winter consumption.

Users of residual fuels find that FOA-2 keeps their fuel storage and supply systems clean and burners operating smoothly.

Diesel Operators

Railroads and other large users of diesel fuels appreciate the economy of cracked distillates stabilized with FOA-2. Filterability is improved and injector sticking problems are reduced.

Being a nonmetallic additive, it does not add to the exhaust stack sparking problem.



FOA-2 with DMD

Pre-mixed combinations of FOA-2 and Du Pont Metal Deactivator are widely used. FOA-208 contains 8% DMD while FOA-212 contains 12% DMD.

A 24-page brochure on FOA-2 with information on properties, concentrations, handling, uses, etc., is available.

Your Petroleum Chemicals Representative will be glad to furnish you with copies of this brochure as well as additional technical information and samples for use with your own stocks, or write Petroleum Chemicals Division in Wilmington.

Golden Gate Office gets new manager

JAMES G. McILHINEY, a veteran with a diversified background in the Petroleum Chemicals Division, and a San Francisco sales representative for more than a year, is now Manager of the San Francisco District.

In his twelve years with Du Pont, Mr. McIlhiney has worked closely with many oil companies in a wide variety of marketing, technical and safety areas. He brings to his present post a thorough knowledge of conditions and needs in the field.

Born in Jersey City, N. J., he went to Cornell University, graduating in 1935 with a degree in Mechanical Engineering. Before joining Du Pont he was associated with Air Reduction Sales Company as a sales representative and engineering specialist.

With Du Pont he has been a sales service representative in the Eastern and Gulf Coast regions. In 1955 he was assigned to the division's technical group in Wilmington, Delaware. He also represented the Petroleum Chemicals Division in the Mid-Continent Region where he remained until early in 1957. Since then he has been a familiar figure in the bay area refineries.

High effectiveness at low concentrations characterizes "Ortholeum" 302 Antioxidant

New Du Pont "Ortholeum" 302 antioxidant has proved, in laboratory evaluations, to be more highly effective at considerably lower concentrations than other currently-used oxidation inhibitors.

A general purpose ashless antioxidant, it is effective as a stabilizer for greases, turbine oils, crankcase oils and synthetic lubricants.

Tests have shown that "Ortholeum" 302 frequently will provide stability for greases which fail to respond to normal concentrations of conventional antioxidants.

In turbine oils concentrations as low as 0.05 to 0.10% by weight are often more effective than higher concentrations of other antioxidants.

Tests have also suggested that "Ortholeum" 302 may prove useful as an auxiliary additive to other antioxidants in crankcase oils. Experiments with a concentration of 0.25 weight per cent in a 400 SUS solvent extracted neutral oil indicated that it did an excellent job minimizing bearing corrosion in a double-length L-4 Chevrolet engine test.

In some synthetic oils, "Ortholeum" 302 frequently exceeds the performance of widely accepted synthetic oil antioxidants in controlling viscosity changes, copper corrosion, and acid number when the oils are subjected to high-temperature oxidation tests.

Your Du Pont Petroleum Chemicals Division representative will be glad to supply more information and samples.

SALES OFFICES

Chicago 3—8 So. Michigan Ave. . . . . RAndolph 6-8630
Cleveland 15—101 Prospect Ave. . . . . MAin 1-3422
Houston 2—
705 Bank of Commerce Bldg. . . . . CApitol 5-1151
Los Angeles 17—612 So. Flower St. . MAdison 4-1354
New York 20—
45 Rockefeller Plaza . . . . . COlumbus 5-2342
Philadelphia 2—3 Penn Center Plaza . LOcust 8-3531
Pittsburgh 22—1 Gateway Center . . . . ATlantic 1-2933
San Francisco 4—111 Sutter St. . . . . EXbrook 2-1934
Seattle 3—4003 Aurora Ave. . . . . MElrose 2-6977
Tulsa 1—1811 So. Baltimore Ave. . . . LUther 5-5578
In Canada—Du Pont of Canada Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12,** Ontario . . . . . HUdson 1-6461
OTHER COUNTRIES:
Petroleum Chemicals Division, Export Sales, Wilmington 98, Delaware . . . . . PRospect 4-2962

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

Du Pont Tetraethyl Lead and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-13616

Printed in U.S.A.

SARCO

Here are 7 Sound Reasons Why the Thermo-Dynamic® Does a Better Job of Trapping

1. *Simplicity*—has only one moving part. 2. *Maintenance*—practically zero. 3. *Wide pressure range*—one trap for all pressures from 10 to 600 psi. 4. *Uniform performance*—operates equally well on heavy, light, or no condensate load. 5. *Operates against back pressures*—up to 50% of inlet pressure. 6. *Rugged*—unaffected by superheat, water hammer, vibration, or corrosive condensate. 7. *Minimizes inventory* of spare parts.

Maintenance Time: 40 Seconds. If it now takes your maintenance crew more than a couple of minutes to service an ordinary trap, you're throwing away valuable time. This Sarco Thermo-Dynamic can be cleaned, blown out if necessary, and reassembled on the line in as little as 40 seconds.

For Prompt Information on the TD-50 . . . or for fast help on the efficient solution of any steam trapping problems, get in touch with a SARCO District Office, Sales Representative, or Distributor. (There's one near you.)

Only SARCO makes all 5 types:

Thermo-Dynamic* • Thermostatic • Liquid Expansion • Float Thermostatic • Inverted Bucket

*U.S. Pat. No. 2,817,353 TM Reg. U.S. Pat. Off. 1409

SARCO COMPANY, INC.
635 Madison Ave., New York 22, N. Y.

Suppliers . . .

Dallas office. He was previously with the Mount Vernon, Ohio, office as a sales engineer. Before joining the company he was associated with Ethyl Corp. and The Texas Co. James is an industrial engineering graduate of Oklahoma State University.

THE INTERNATIONAL NICKEL CO. OF CANADA, LTD. has named **William K. Whiteford,** president of Gulf Oil Corp., a member of its Advisory Committee. Before joining Gulf in 1951, he lived in Toronto, where he headed British American Oil Co., Ltd. After joining B-A in 1942, he was elected president in 1943 and chairman of the board in 1951. Whiteford is a director of Mellon National Bank & Trust Co., General Motors Corp., Jones & Laughlin Steel Corp., Procter & Gamble Co., Stouffer Corp., Bank of Nova Scotia and Canada Life Assurance Co.

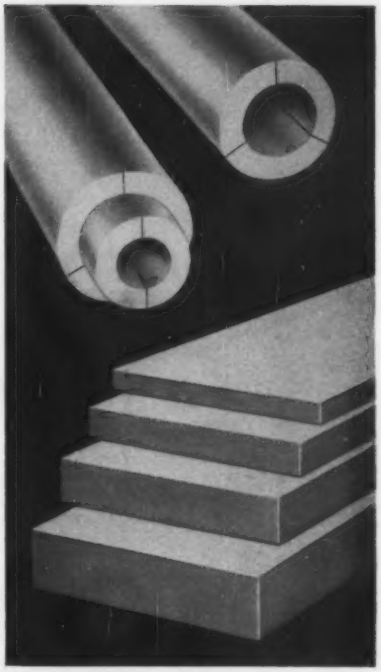
BECKMAN INSTRUMENTS, INC.'s Electrochemistry Group, Scientific and Process Instruments Division, has named **Dr. George Matsuyama** senior chemist. He will do research on electrochemistry and electrochemical instrumentation. Dr. Matsuyama received his B.S. degree in chemistry from the University of California at Berkeley and his Ph.D. degree in physical chemistry from the University of Minnesota. From 1942-48 he was an instructor in analytical chemistry at the University of Minnesota.

NALCO CHEMICAL CO. has promoted **Dr. John W. Ryznar,** vice president and technical director of the company to technical representative in corporate management. He will be responsible for planning, guiding and coordinating all technical activities of the company and its subsidiaries. Dr. Ryznar joined Nalco as a research chemist in 1937 and was named research director in 1945, technical director in 1950, and vice president in 1957.

HALL LABORATORIES, a division of Hagen Chemicals & Controls, Inc., has named **H. M. Rivers** assistant district director. He was formerly director of engineering services. **Leonard Highley, Jr.,** headquarquarters staff engineer, succeeds him as manager of engineering services. Rivers assumes responsibility for long-range planning in research and development, and improvement of Hall's system for collecting and distributing information on industrial water problems.

NAPCO INDUSTRIES, INC. has named **J. E. Stilwill** regional manager of the California, Nevada, Utah, Arizona, New Mexico, Colorado and Wyoming areas. **M. L. Garrettson** has been named regional manager of the Washington, Montana, Idaho, Oregon, Alberta and British Columbia areas.

MALONEY-CRAWFORD TANK AND MANUFACTURING CO. has appointed **Samuel A. Wilson** manager of manufacturing. Previously with Fansteel Metallurgical Corp. as assistant to the vice president and as



RUBEROID®

CALSILITE INSULATION

The one-layer insulation for soaking heat up to

1250° F.

CALSILITE is the ideal molded calcium silicate insulation for today's high temperature, high pressure process and power piping and vessels. A single layer provides a constant coefficient of conductivity. Here are a few of its many outstanding advantages:

- **Withstands normal acids and alkalis**
- **Insoluble in water**
- **Absorbs moisture without disintegration**
- **Resists abuse**
- **Lightweight, easy to cut, mitre, and apply**
- **Available in various thicknesses, in half-sectional, three segmental, and block form.**

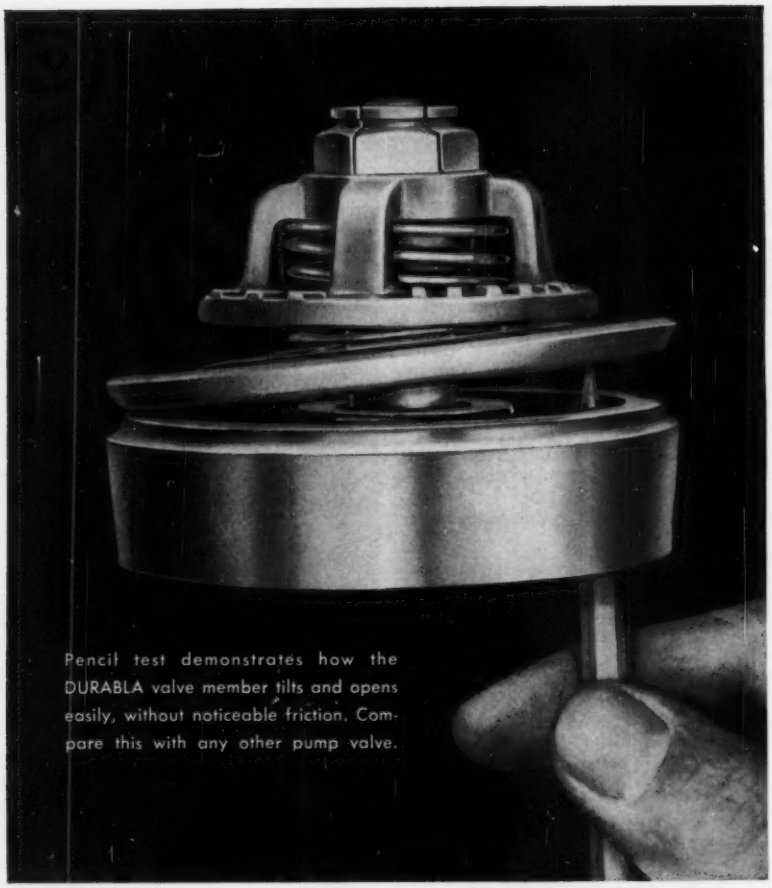
For complete details, see
Chemical Engineering Catalog
Refinery Catalog • Sweet's Catalog

Send your inquiry to:

The RUBEROID Co.®
INDUSTRIAL PRODUCTS DIVISION
500 Fifth Ave., New York 36, N.Y.

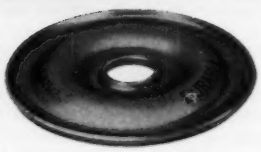
PIONEERS IN CALCIUM SILICATE INSULATION

For more data on advertised products, use Readers' Service Cards, last page.



Pencil test demonstrates how the DURABLA valve member tilts and opens easily, without noticeable friction. Compare this with any other pump valve.

NO. 1 REASON



this is the ideal valve for high-speed pumps

Key to the high efficiency and free action of a DURABLA V-7* Pump Valve Unit is the patented lightweight valve member. Making only "point contact" on the sleeve, it can't bind or hang up. Nor can it warp, thanks to its unique arched design.

This low-lift valve member is designed to open with a tilt, following the flow lines. Valve action is very sharp, thanks to lightness and flexibility. That's why DURABLA is the only valve ideally suited to high-speed operation.

DURABLA valve units operate freely under temperature-pressure extremes, with corrosive fluids and in any position. Available in 17 sizes, they will meet over 300 variations in installation requirements.

Send for booklet PE-30

DURABLA MANUFACTURING COMPANY
114 Liberty Street, New York 6, N. Y.

DM-35

*Patent applied for

DURABLA®

Manufacturers of DURABLA sheet packing, gaskets and check valves

Suppliers . . .

superintendent of the Metals and Chemical Division, Wilson was graduated from the University of Oklahoma with a degree in chemical engineering. He also holds a M.B.A. degree from the Harvard Graduate School of Business Administration.

CROUSE-HINDS CO. has named **Richard W. Scott** administrative engineer, Engineering Division, Syracuse, N.Y. Scott returned to Syracuse recently from Detroit where he has been Great Lakes Division manager since 1957. A graduate of Syracuse University, he is a member of AIEE and the International Association of Electrical Inspectors.

HARCO LABORATORIES, INC. has appointed as sales representatives, Paul R. Sturgeon, Inc., Boston (for the New England area) and G. W. Moler Co., Erlton, N.J., for Maryland, Delaware, Virginia, District of Columbia, Eastern Pennsylvania and Southern New Jersey.

JONES & LAUGHLIN SUPPLY DIVISION has named **L. B. Rainey** assistant manager of sales and projects, Houston. With the company since 1936, he has been in sales since 1938. Before being assigned to Houston, Rainey held the same position in the Tulsa office.

PYROMETER CO. OF AMERICA, INC., manufacturers of thermocouples and pyrometric accessories, has appointed Clifford B. Ives & Co., Inc., Narberth, Pa., as its representative in Eastern Pennsylvania, South and Central New Jersey and Northern Delaware.

H. K. PORTER CO., INC.'s Mouldings Division has changed its name to Coldform Division. The division serves the automotive, electrical appliance, aircraft, boat building, electronics and construction industries from plants located at Detroit and Frankfort, Ky.

FOOD MACHINERY AND CHEMICAL CORP. has named **Donald C. Oskin** vice president of executive sales for the chemical divisions. He has also been appointed a member of the chemical divisions' Executive Committee. Oskin will maintain contact with top management of FMC's five chemical divisions' major customers. These divisions are Becco Chemical, Chemicals and Plastics, Chlor-Alkali, Mineral Products and Niagara Chemical.

Test Yourself on Labor Relations
(Answers)

CASE 1

Arbitrator George Savage King ruled: "Mr. Max Winkle is not an unsophisticated, uneducated shop worker who might be expected to give vent to emotional outbursts under pressure. On the contrary, he impressed the Arbitrator as a man very well trained in the

For more data on advertised products, use Readers' Service Cards, last page.

Have you ever been troubled by any of these steam trap problems?

ARMSTRONG STEAM TRAPS are designed and made to eliminate these problems

BACK PRESSURE . . . Armstrong Traps operate on any back pressure—or vacuum, for that matter. As long as there is a pressure differential across the trap, it will close on steam and open for condensate. Even the high back pressure caused by blow through of one or more traps in the system will not disturb Armstrong Traps. Other than a reduction in capacity, Armstrong Traps are unaffected by back pressure.

DIRT . . . Armstrong Traps are not affected by ordinary dirt. When the trap opens condensate swirls down under the edge of the bucket and up through the discharge orifice. Dirt is kept in suspension and discharged along with the condensate. For very bad dirt conditions, Armstrong offers traps with integral strainers. These cost less than a trap plus a separate strainer.

AIR BINDING . . . Armstrong Traps cannot air bind. Air in the system passes through a vent in the top of the bucket. It collects in the top of the trap and is discharged with the condensate. There is no chance for it to stop the trap. For low pressure on-and-off units where large amounts of air accumulate while the steam is off, Armstrong offers open float and thermostatic air vent traps in a complete range of sizes.

WIRE DRAWING . . . Armstrong Traps are designed and made to resist wire drawing. The valve and seat are tough stainless steel. The valve opens and closes tightly with a fast action and is always water sealed. There is virtually no chance for grit or sediment to lodge in the valve, virtually no chance to create conditions that lead to wire drawing.

There's no need to accept any of these problems as "inevitable." Your local Armstrong Representative can show you how to end them all. Call him today or write direct.

860 Series for low pressure heating service.

800 Series, side inlet, side outlet.

No. 801, side inlet, bottom outlet.

880 Series, integral strainer.

200 Series, bottom inlet, top outlet.

Forged Steel Series for high pressures, high temperatures.

The 48 page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

ARMSTRONG MACHINE WORKS
8522 Maple Street Three Rivers, Michigan

For more data on advertised products, use Readers' Service Cards, last page.

SITUATIONS WANTED

■ B.S.P.E., 25, single, ambitious, 3 years experience technical sales calling on steel, carbon, refinery and iron industries. Seeks similar position in Dallas, Texas area. Box 333-R, PETROLEUM REFINER, Houston, Texas.

HELP WANTED

INSPECTION ENGINEER

Expanding Chemical Division has opportunity for graduate engineer, 1-5 years experience in inspection or maintenance engineering in chemical, petrochemical or petroleum industry. Working knowledge of corrosion mechanisms and controls required; nondestructive testing procedures and instruments, welding and protective coatings experience desirable. Send complete resume including present salary to: R. S. Buell, Pittsburgh Coke and Chemical Company, Pittsburgh 25, Pennsylvania.

Process and Project Engineers
Instrument Engineers

Leading national engineer—constructor of polymer and chemical plants, needs chemical and mechanical engineers to assist in design of plants equipment and pilot units for advanced new polymers and chemical. Polymer and monomer plant experience with operating or contracting organizations desirable. All benefits, highest professional atmosphere. Pleasant suburban living. Please send us resume in complete confidence.

CRAWFORD & RUSSELL, Incorporated
695 Summer Street, Stamford, Connecticut

SENIOR INSPECTION ENGINEER

Heavy Chemical Producer has desirable opening for graduate chemical, metallurgical or mechanical engineer to supervise inspection section of large engineering department. Eight to ten years experience of actual field inspection of plant equipment in chemical, petroleum or related industry required. Please submit resume with present salary with first letter. All replies confidential. Box 334-R, PETROLEUM REFINER, Houston, Texas.

Send for your **FREE** copy of the **New Petroleum Books Catalog** containing descriptions of many books pertaining to the Petroleum Industry. Send your request to **Book Department, Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.**

HELP WANTED

INSTRUMENTATION ENGINEERS

Engineering degree and 3 years recent experience in operation, application, specification and selection of instrumentation and electronic and pneumatic controls for Refineries and Chemical Plants. Openings in our Cleveland offices.

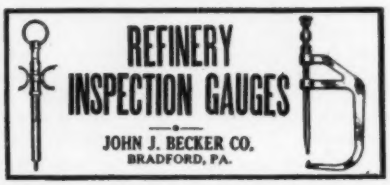
Send detailed resume to:
G. VICTOR HOPKINS
ARTHUR G. McKEE & CO.
2300 Chester Ave., Cleveland 1, Ohio

Chemist or Chemical Engineer

With Broad Knowledge of Refining Industry for technical writing and editing on refining industry motor fuel, lubricants, petrochemical and related fields. Prior writing or editing experience desirable. Creative, important job. Send resume to:

PERSONNEL DIRECTOR
ETHYL CORPORATION
1600 West Eight Mile Road
Ferndale 20, Michigan

FOR SALE



If you want
fast
results . . . use
Petroleum
Refiner
classified ads
They don't cost,
they pay.

Answers

(continued)

business in which he engaged—intelligent, articulate, extremely self-confident and entirely capable of self control.

"He knew that any grievances that could not be satisfactorily settled with the company could be taken to arbitration, but he preferred to create an air of intimidation in his discussion with the employer. That this was his preference is indicated by his testimony that he stepped around the desk and talked into the employer's face because it was something he often did. Whether this was Mr. Winkle's usual manner of discussing a grievance or not, it was the kind of conduct which the employer had a right to resist, and if need be, with force.

"Across an office desk is close enough for collective bargaining; to move around a desk toward the other party in the midst of a heated discussion can have only one purpose—the use of force or a threat of the use of force. Neither Labor Relations nor labor unions can afford to condone such conduct—to do so is to invite public censure. It is the finding of the Arbitrator that Mr. Winkle's conduct justified the company in refusing him access to the premises."

CASE 2

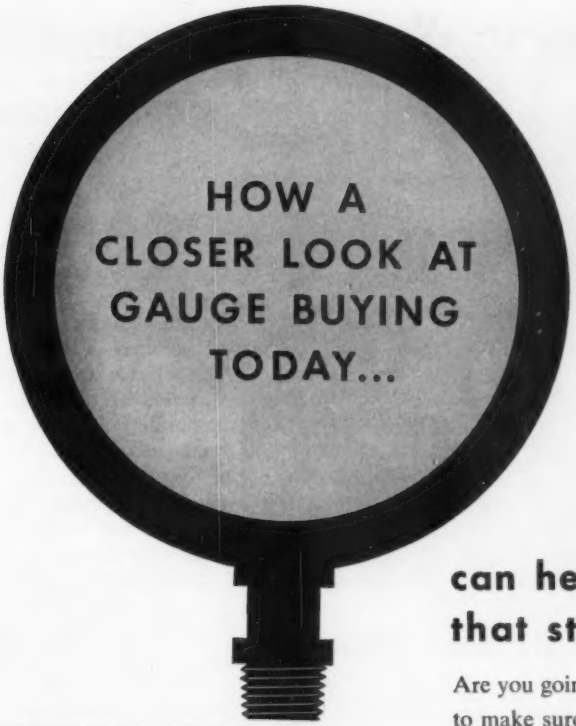
A Board of Arbitration ruled: "The basic issue is whether the company violated the agreement by selecting a probationary employe. In the opinion of the Arbitration Board, John Kelso was the most highly qualified person to fill the job. His experience put him head and shoulders above the other three employes who had no such experience.

"However the matter of seniority is involved. Section C of Article XVII specifically required that due consideration shall be given to three factors: seniority, qualifications and ability, and physical fitness. A careful reading of the Seniority Article would lead to the conclusion that an employe must possess, in varying degrees, all three factors, including seniority.

"It was stipulated that Kelso had *no* seniority when he was selected. He was still a probationary employe. Section A explicitly provides that during such probationary period he shall not be regarded as a 'regular employe.' Since he was not a regular employe he had no competing rights in the 'application of seniority.' Thus, despite his excellent qualifications, he was *not eligible* to be considered to fill the vacancy as long as other employes with seniority had also bid for the same job."

CASE 3

Arbitrator Paul H. Sanders ruled: "Management is entitled to make reasonable rules regarding absenteeism and has a right to require that employes give notice of absence. John Gregg had an obligation to call the company after the first day's absence and get approval for additional days off. His failure to let the company know of his return, plus his previous record of excessive absenteeism do not entitle him to reinstatement. The company's action was justified."



can help you pick gauges that stay on the job

Are you going to a higher price on gauges in order to make sure of gauge reliability? "Over-gauging" to get long life? It will pay to take a closer look at the size, flexibility, and high standards of accuracy of the United States Gauge line. At USG you can choose from over 50,000 standard indicating dial pressure gauges. Thousands of choices in case styles, sizes, materials, and in gauge components. Thousands of specials, too! Not only can you pinpoint your *reliability factor*, you can pinpoint your *price* for 99% of your gauge needs . . . from one line! It's easy to check . . . just call your USG distributor for your next gauge requirement. See the Yellow Pages, or write for catalogs and name of your distributor.

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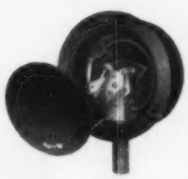

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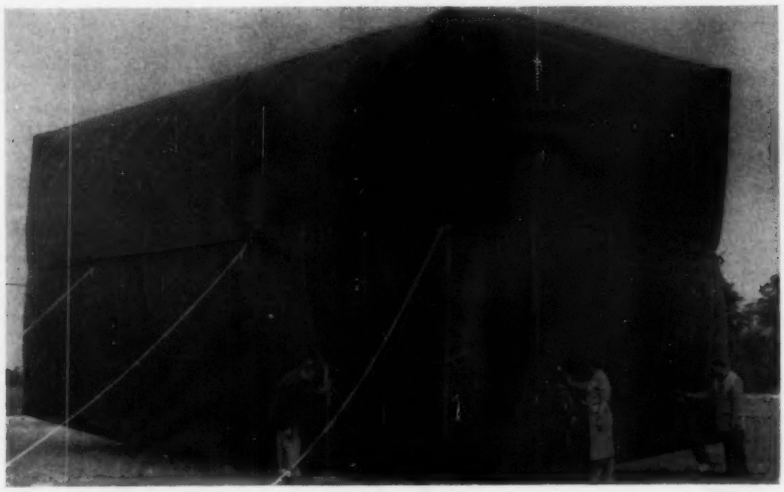


Lung Recovers Gasoline Storage Vapors

This 20,000-cubic-foot breather balloon has been test inflated in preparation for its role in conservation of gasoline vapor at a petroleum refinery, overseas.

In actual operation, expanding vapors from gasoline in storage are piped through the two aperture sleeves in foreground. The bag will be suspended off the ground, inside a shelter, for unrestricted inflation and deflation. Suspension will be made from the girt attached at the horizontal center line. The Garrett Corp.

Circle E1 green card, last page

Gasoline Additive Gives Significant Octane Bonus

Tetramethyl lead (TML) is ideally suited for use as an antiknock agent in gasolines produced by the new platinum-catalyst reforming processes which are the backbone of high-octane gasoline production. The chief benefit of TML is in overcoming knock due to "fuel segregation," a separation of the more volatile and less volatile portions of gasoline in the intake manifold of an engine. The resulting non-uniform mixtures reaching the cylinders cause knock when it would not otherwise occur. Surveys have been made of "fuel segregation" tendencies of cars produced throughout the Free World. These have shown that a high percentage of automobiles with manual transmissions exhibit "fuel segregation," regardless of country of manufacture. A smaller percentage equipped with automatic transmission exhibit "fuel segregation." Under these conditions TML gives higher (2 to 6 O.N.) road octane numbers than tetraethyl lead. Socony Mobil Co., Inc.

Circle E3 green card, last page

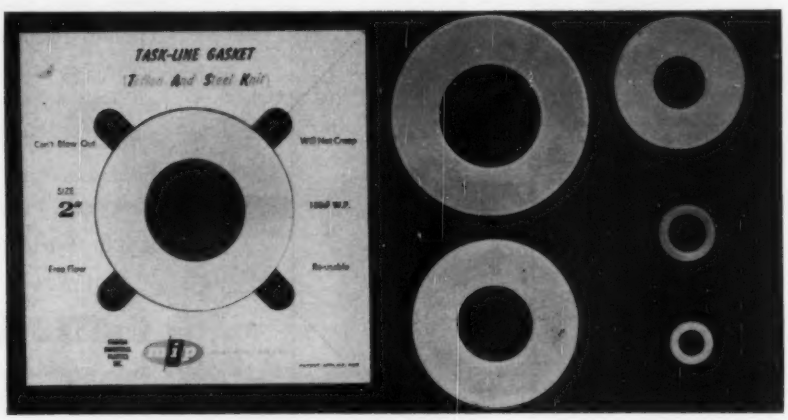
Dust Scrubber Ideal for Handling Catalyst Fines

A new high-energy dust and fume scrubber, the Oriclone, has just been introduced. The scrubber is one of the few wet collectors whose performance can match that of the electrostatic precipitator. It is ideally suited for control of acid mists, tar fog, petroleum coke dust, catalyst dusts and other fine particles.

A unique feature of the scrubber is its adjustable rectangular orifice, which is advantageous in processes where operating conditions vary.

Compactness of the scrubber results from the fact that the high energy at the orifice is used to atomize, agglomerate and separate the particles. Introduction of the jets of water against the orifice plate, rather than in the throat of the inlet as in other orifice-type scrubbers, results in improved water distribution across the orifice. There is a reduction in power consumption, facilitating improved dust and fume separation. The Ducon Co., Inc.

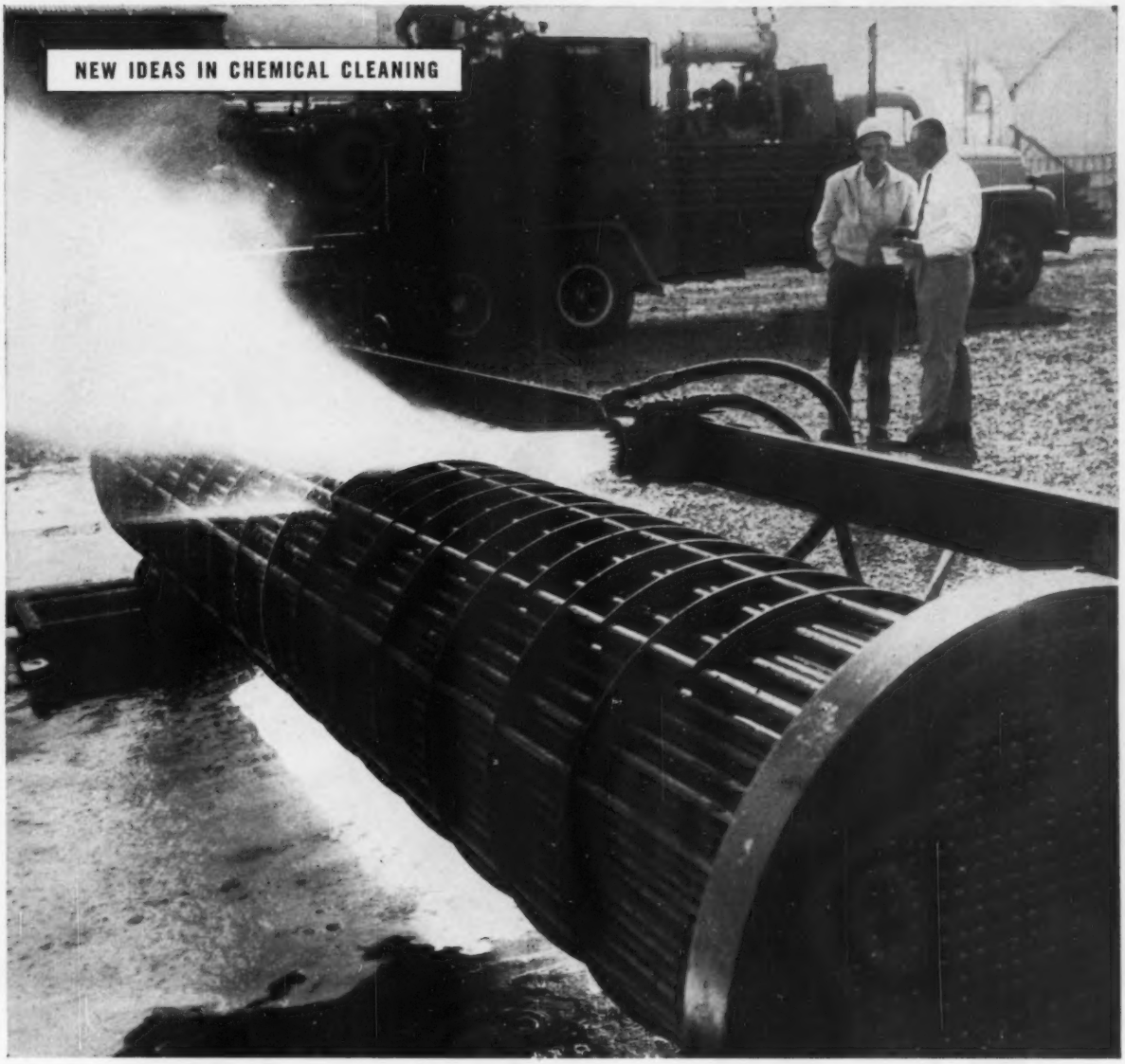
Circle E2 green card, last page



Package Makes Gasket Installation Easy

A complete new line of pipe gaskets, called the Task-Line, from the Teflon and steel knit used in its manufacture, is being introduced for use in the chemical and other refining where a superior Teflon gasket is required.

One of the most important features of this line is that each gasket is packaged in a disposable cardboard template for easy installation. Use of the cardboard, effective but inexpensive, for "positioning" the gasket eliminates many difficulties experienced in the past—particularly when gasket material did not extend beyond the dimensions of pipe flanges. Installation is easy in these four steps: Remove the cellophane tape; insert the gasket and cardboard template into position; place bolts through the template holes



New Jetting Tool To Clean Tube Bundles Saves Thousands Of Dollars

The new high-pressure hydraulic tool, shown above, is currently saving thousands of dollars for companies in the refining, chemical, and petrochemical industries. It is the jetting tool developed by Dowell to remove deposits from heat exchanger tube bundles.

Previous methods of cleaning these bundles have been costly, time-consuming and often inadequate. Many times bundles had to be replaced completely because of the lack of a suitable cleaning method.

This new tool has a remarkable record of thorough, fast cleaning. For example, a slurry reboiler exchanger bundle, three feet in diameter and 16 feet long, was fouled with deposits of coke and asphalt. After being jetted from only one side, the bundle was thoroughly clean. Time required: less than one hour.

The tool holds the bundle in place for cleaning and has flanged rollers for rotation. The jet-head is manipulated automatically so that all tube spaces are covered. The jetted liquid can be either water or chemical solvents.

The new Dow Industrial Service Division will continue to offer the service which was formerly provided through the Dowell Division. For engineered recommendations to solve your cleaning problems contact the field office nearest you, or write Dow Industrial Service, 20575 Center Ridge Road, Cleveland 16, Ohio.

DOW INDUSTRIAL SERVICE

DIVISION OF THE DOW CHEMICAL COMPANY

DOW

For more data on advertised products, use Readers' Service Cards, last page.

IN A FIVE-MINUTE TELEPHONE CONVERSATION . . .

This gas processing specialist helped an operator save $3,000 a day

Recently, a West Texas natural gas processor called stating he was flaring sales gas due to high sulfur content caused by foaming in an ethanolamine system. The same antifoamants used successfully for some time were not effective. Subsequent questioning revealed that his gas stream was now at a higher temperature than the amine and a condensation of hydrocarbons resulted. On-the-phone-solution . . . raise the amine temperature to approximately 15° F. above that of the gas stream.

This, of course, was a simple one. More often Jefferson's experienced gas treating specialists will probe for pertinent data, request samples, and coordinate the solution of your problem through Jefferson's Austin Laboratories. Whether your problems be in desulfurization or dehydration . . . corrosion, foaming or contamination . . . Jefferson can draw on a vast fund of case experiences to help you avoid costly shutdowns, gas flaring or excessive solution losses.

For the *right* gas processing answers and chemicals . . . call Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

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and tighten; then tear out the template.

The gaskets are available for immediate delivery in five different flange pipe sizes—½, ¾, 1, 1½, and 2 inches—and are for the 150-pound series. Standard gaskets are 1/16-inch thick. The ⅛-inch and special thicknesses can be made on special order. Modern Industrial Plastics Div., The Duriron Co., Inc.

Circle E4 green card, last page

Steam Trap Has Union Built Into Trap Inlet

A new model thermostatic steam trap has been placed on the market with a union incorporated into it which reduces initial cost of trap installation and maintenance. Designed into the inlet of the trap, the union eliminates the time involved in fitting the pipe to a union, as well as the cost of purchasing a separate union and materials. In addition, maintenance is simplified because the trap can be disconnected by loosening a single fitting.

The built-in union feature is available as an optional feature at slight extra cost on Quik-Flex Thermostatic Steam Traps in both ½ and ¾-inch sizes. The V. D. Anderson Co.

Circle E5 green card, last page

Polypropylene Ring Tower Packing In Four Diameters

A new polypropylene Pall Ring tower packing has been developed which combines light weight and a wide chemical-resistance range with virtually the same low pressure drop and high mass transfer efficiency as metal Pall Rings.

Because they weigh only about 4½ pounds per cubic foot, polypropylene Pall Rings can be packed to a height of at least 25 feet per support plate. This provides worthwhile economies in tower support plates and, in many instances, in tower construction.

Currently available in four standard sizes—⅝, 1, 1½ and 2-inch diameters—polypropylene Pall Rings are inert to a large number of organic and inorganic chemicals that would rapidly corrode the most costly metals. They can withstand continuous operating temperatures up to 250° F. The U. S. Stoneware Co.

Circle E6 green card, last page

Inhibitor Stops Sludge Formation In Fuel Oil

Development of effective dispersants and inhibitors which prevent formation of sludge in fuel oil is described in a newly published booklet.

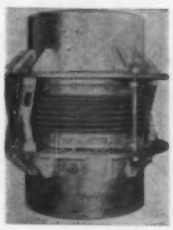
After seven years of screening 300 chemicals, a group of fatty amine derivatives called Armolads have been developed as effective inhibitors. Two dialkyl dimethyl ammonium chlorides, trade named Arquad 2HT and Arquad 2S, were found to be useful as dispersants.

The inhibitors are effective in most crude stocks for a year or longer. They stabilize the oil against gum formation and color degradation at a cost as low as eight cents per barrel or less. Armour Industrial Chemical Co.

Circle E7 green card, last page

Hinged Expansion Joints Eliminate Added Supports

A hinged-type expansion joint for piping systems that, because of their size or location cannot be supported or anchored by conventional means, has been developed. These joints permit a piping system to be entirely self-supporting. This eliminates the need for additional supports and reduces pipe-line bending stresses. Movement is more closely controlled than with any other type of expansion joint.



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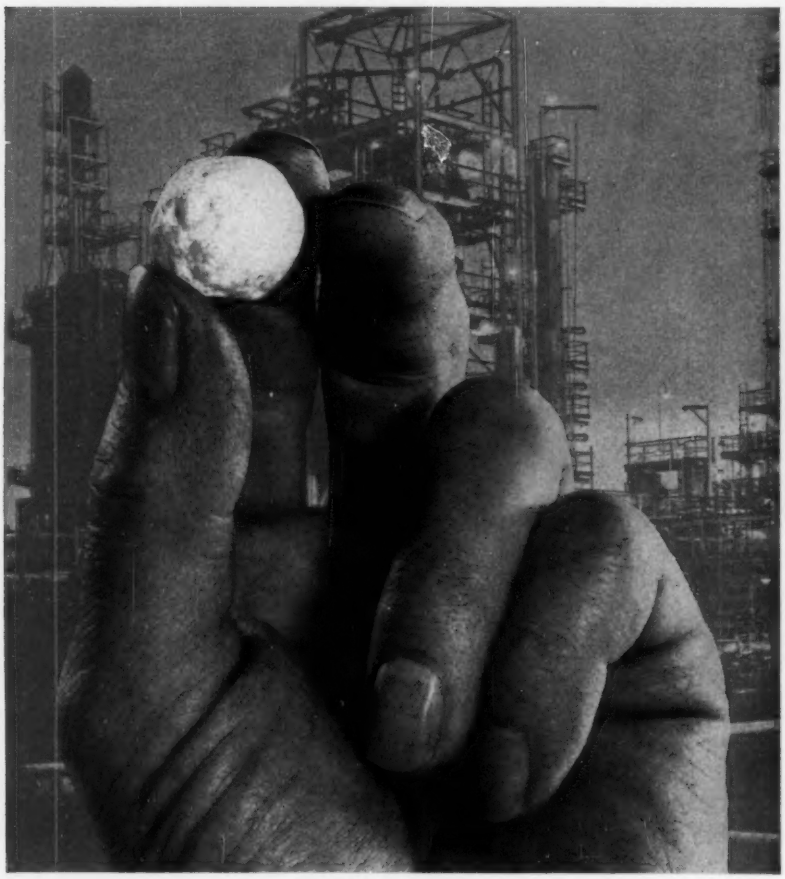
This Porter Mullite Pellet costs up to 50 per cent less!



Porter Mullite Pellets actually do cost up to 50 per cent less than most catalyst bed support materials now available. *And you make no operational sacrifice to gain this savings!*

Porter mullite pellets have been commercially tested for over three years, as inert support for active catalyst, in many major refineries. They've withstood all the trials of heat, shock and pressure without breaking or dusting. Porter mullite pellets have successfully resisted abrasion, erosion and crushing . . . completely protecting the valuable catalysts from contamination.

Convert to Porter mullite pellets now, and reflect these important cost-savings in your refining process. For complete information, write: *Refractories Division, H. K. Porter Company, Inc., Porter Building, Pittsburgh 19, Pennsylvania.*

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Equipment . . .

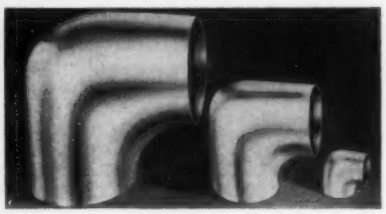
ringed expansion joints, which can also absorb piping weight, wind loads, and other dead loads without extensive anchoring. Bellows torsion is prevented and the resulting piping system is more stable than with other types of expansion joints.

The standard-model hinged expansion joint is designed to take rotation in one plane only. For this reason, these expansion joints are used in combinations of two or three. Zallea Brothers.

Circle E8 green card, last page

Aluminum Elbows Protect Against Insulation Cracks

Humped aluminum elbows are designed to cover and protect the "weakest links" in every plant's insulated piping

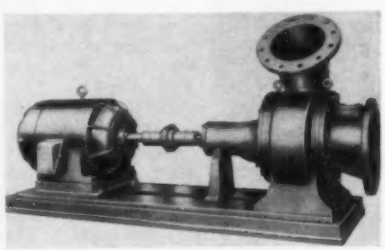


system at all "joint cracks." The humped design automatically compensates for pipe expansion and contraction and for differences in radii that vary with pipe sizes and insulation thickness. As a result, with only 13 interchangeable sizes, the elbows will fit 109 combinations of varying pipe sizes and insulation thicknesses ranging from 3 through 12.81 inche OD. General American Supply Corp.

Circle E9 green card, last page

Heavy-Duty Process Pumps For Heavy Oils and Slurries

Designed to meet the most severe operating conditions encountered in the process and allied industries, a broad line



of heavy-duty process pumps has been developed. They have a capacity range up to 9,500 gpm and for heads up to 220 feet.

The pumps are of the end-suction, vertically-split type, featuring back pull-out assembly which gives ready accessibility to all rotating parts without disturbing pipe connections. All pumps have 45-degree self-venting discharge connections as standard. They feature top hori-

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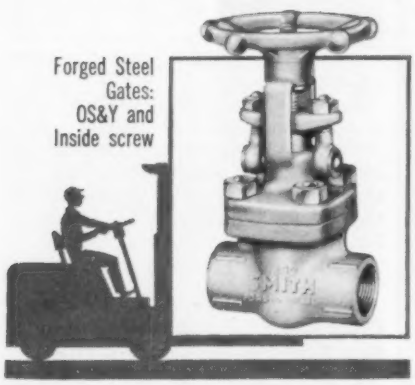
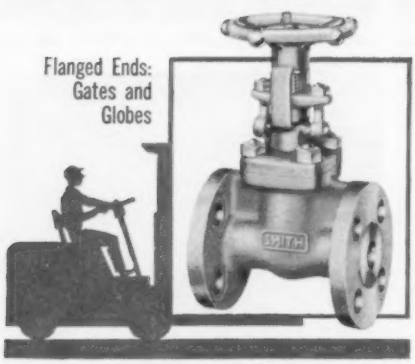
to provide the Refinery, Chemical and Petrochemical Industries in that area with faster deliveries from a complete stock of SMITH Forged Steel Valves.



Forged Steel Gates: OS&Y and Inside screw

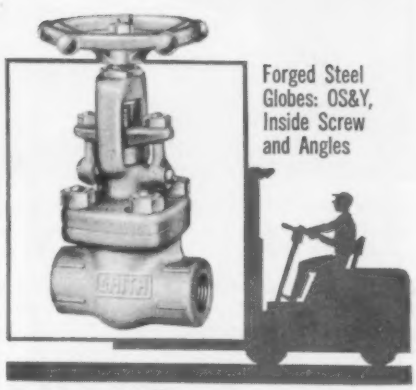


Flanged Ends: Gates and Globes

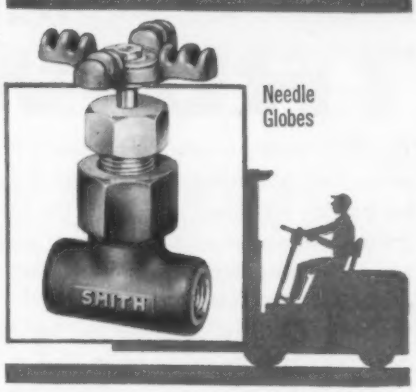
In selecting the small utility valves to be used in their plants, engineers and maintenance men give primary consideration to PERFORMANCE—the ability of each valve to give long, trouble-free life in service. Of secondary importance, perhaps, but still a vital factor, is the element of TIME as applied to deliveries.

That SMITH Forged Steel Valves are now in regular service in so many major refineries, chemical and petrochemical plants is proof—positive of their efficient PERFORMANCE.

To our West Coast friends and customers, the opening of our new factory warehouse in Gardena, California, means that when TIME is important, quick service is available from a complete stock of SMITH Valves now located nearby.



Forged Steel Globes: OS&Y, Inside Screw and Angles



Needle Globes

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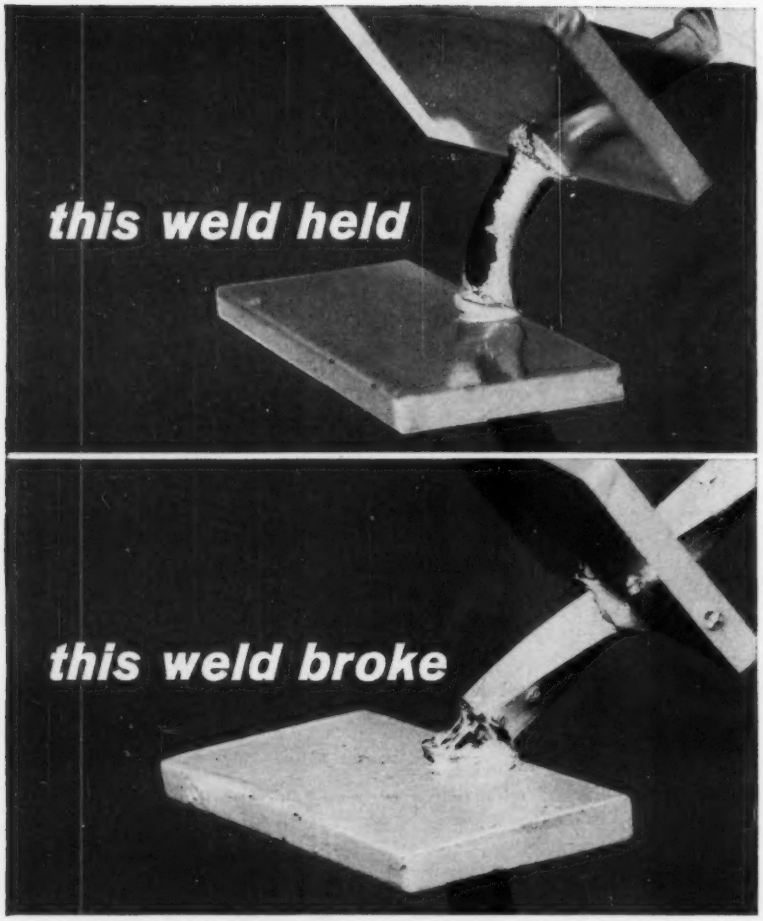


(Above) This DRAVO TRU-WELD GRATING was deliberately bent, placing far more strain on the welds than there would be in normal service. Not a single weld has parted. This grating will withstand vibration and hard usage.

(Below) **Bent in exactly the same way,** this grating came apart at the welds. The fusion of bearing bar to cross bar achieved by the Dravo method of manufacture prevents this from happening to Tru-Weld Grating.

the new stronger grating is TRU-WELD

Tru-Weld grating is stronger because it is *made* that way. Its added strength comes from a manufacturing process that completely fuses the metal at cross bar-bearing bar joints and holds the bars to exact spacing. The result is grating that stands up under excessive vibration, heavy traffic or in areas where corrosive fumes and moisture are a problem. And Dravo Tru-Weld grating *costs no more.*

Complete estimating, layout and fabricating services are available. Immediate delivery from stocks maintained at nearby Joseph T. Ryerson Service Centers will help you meet exacting construction schedules.

For more information on this new, stronger grating — call the Dravo representative in your area, or write Dravo Corporation, Pittsburgh 25, Pa.

DRAVO
CORPORATION

Equipment . . .

zontal or vertical-up discharge can be furnished on special order. Non-clogging, solids-handling impellers with back-ejector vanes, external adjustment of clearance between impeller and renewable side plates, split glands suitable for quenching, and cooling chambers on bearing housings. These pumps are particularly suited for heavy-duty 24-hour service with minimum maintenance. Seven types of materials of construction are available, including stainless steel. Goulds Pumps, Inc.

Circle E10 green card, last page

Recorder-Receiver Features Faster Power Positioner

Design features of several new, more sensitive and versatile Chronoflo recorder-receiver arrangements

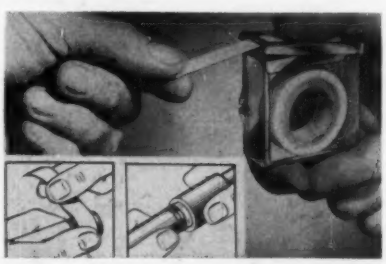
include a newly-engineered power positioner. It features faster, quieter response—2, 4, 8, 15 and 60-second time-cycles; up to 16 control switches for alarm and control functions; a swing-out panel for easy access; modular construction and multiple pen arrangements.

For telemetering flow, pressure, temperature, level, position, RPM, and electrical quantities, the new Chronoflo is compatible with supervisory control systems employing tone, micro-wave or radio-transmission links. B-I-F Industries, Inc.

Circle E11 green card, last page

Pipe-Joint Tape Dispenser For Simple Tape Handling

A snap action, clean cutting dispenser for Thred-Tape pipe joint sealer has just been introduced. This dispenser incor-



porates a cutting assembly made of chrome-plated steel with a tempered and ground edge which is clamped on a clear plastic container. It also provides a simple, efficient and dirtproof means for handling the tape and constantly shows the amount available.

Thred-Tape is the new thread sealer that seals connections under the most

Refinery licks tough heat exchanger crisis with emergency tube service

A sudden tube failure at the Pure Oil Company's Refinery in Lemont, Illinois, recently put Bridgeport's condenser tube service to the test. The failure hit on Friday afternoon—just before business slowed down for the week end. Faced with the prospect of costly equipment down time, the refinery called Bridgeport's Chicago office to find out how fast new tubes could be supplied. Here's a round-the-clock story of how the emergency was licked.

Friday, 2:30 P.M.: Salesman from Bridgeport's Chicago office learns that Pure Oil needs 900 Admiralty condenser tubes, and fast.

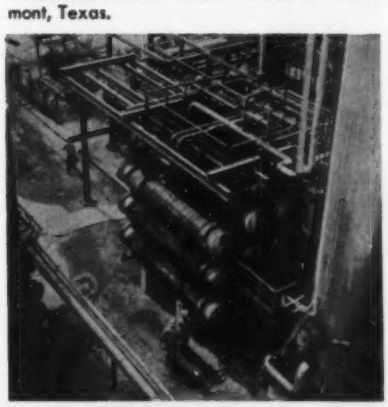
Friday, 3:00 P.M.: Salesman contacts our Bridgeport, Connecticut, mill and is informed that order can be delivered to Pure Oil Refinery in one week.

Friday, 3:30 P.M.: Sudden change in customer's needs makes immediate delivery of tubes imperative.

Friday, 4:15 P.M.: Chicago office checks through coast to coast network of Bridgeport warehouse stocks. Locates tubes at Beaumont, Texas.

Friday, 4:30 P.M.: Special night shift at Beaumont is put on job to cut tubes to special lengths and pack for shipment.

Saturday, 4:00 A.M.: Special truck leaves Beaumont, Texas, with order for Pure Oil Refinery in Lemont, Illinois.



Sunday, 11:30 P.M.: Truck arrives at Lemont Refinery with 900 Admiralty tubes, ready for repair work to start Monday morning.

While emergencies like this don't happen every day, they do prove dramatically that Bridgeport's customer service can come to the rescue. When we talk about fast service from our network of sales offices and warehouses, we mean it. Let us tell you more about our service on your condenser and heat exchanger tube needs, whether they're emergencies or normal deliveries. Call your nearest Bridgeport Sales Office, or get in touch with us direct.

Write for your free copy of Bridgeport's Condenser and Heat Exchanger Tube Handbook. (Dept. 5302)

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut • Sales Offices in Principal Cities

Specialists in Metals from **A***luminum to* **Z***irconium*

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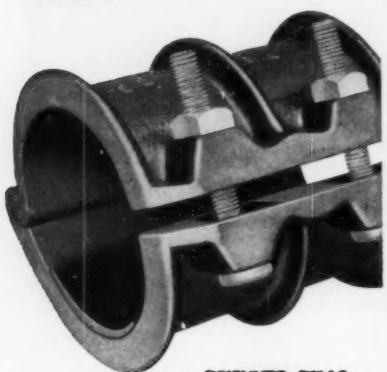
SKINNER-SEAL
PIPE JOINT CLAMP STOPS LEAKS
at joint where pipe is screwed into fitting

SKINNER-SEAL
PIPE JOINT CLAMP stops leaks at joints where pipe is screwed into fitting. Any temperature—any pressure up to 2,000 pounds. Saves the cost of tearing out and renewing leaky fittings. Prevents shutdowns. In stock at most oil supply stores.



SKINNER-SEAL
EMERGENCY PIPE CLAMPS for safe, sure, lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12," for steel and C.I. pipe. Stocked by practically all oil supply stores.

Complete line of Repair Clamps. Send for Catalog 54!

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

Equipment . . .

difficult service conditions, including practically all corrosive chemicals, caustics, hydraulic and aromatic fuels. It prevents seizing and galling, is self lubricating to permit connections to be drawn to a maximum degree of tightness, yet remains plastic so that connections can be easily disassembled at any time. Temperature range is from —250° F to +500° F, and pressure range to thousands of pounds. Crane Packing Co.

Circle E12 green card, last page

Tantalum Tubing 60 Feet Long Made for Exchangers

Seamless tantalum tubing in lengths up to 60 feet are being produced. Previously, seamless tantalum tubing was available only in shorter lengths. This limited its applications in the process industries, which often requires tubing in lengths of 30 or more feet for the production of heat exchangers and acid concentration equipment.

Seamless tantalum tubing is available in sizes ranging from 0.453 to 1.5 inches outside diameter and in wall thicknesses ranging from 0.015 to 0.125 inch, and in lengths up to 60 feet. Wolverine Tube Div. Calumet & Hecla, Inc.

Circle E13 green card, last page

Check Corrosion Resistance Of Materials By New Chart

A new 4-page Corrosion Resistance Chart lists more than 150 different chemicals and their recommended usage with ductile iron, iron, steel, 316 and 304 stainless steel, monel, brass, bronze, copper, aluminum and plastisol plastic. The chart also shows which gasket materials are needed for the various chemicals when Kamlok Quick Couplers are used and which O-ring materials are needed when swivel joints are used with these chemicals and compounds. OPW-Jordan Corp.

Circle E14 green card, last page

Super-Sensitive Corrosion Probe Checks Metal Loss

A corrosion measurement probe which checks electrical resistance has been announced. The main use of the new probe will be in measuring hard-to-detect liquid and gaseous contaminants. It can detect the slightest change in humidity, ozone concentration, water content in a non-aqueous liquid, or other environmental conditions which have a tendency to attack metal.

The essential element of the probe is a vacuum-deposited film of metal, 2 to 50 millionths of an inch thick. The metal varies with the application, but usually is one which is readily attacked by the compound being measured. Because the instrument connected to the probe can

For Uniform QUALITY
Specify CHICAGO-WILCOX GASKETS

RING GASKETS
For ring-type flanged joints in high-pressure lines. Made of soft iron, standard steel alloys or any non-ferrous metal to any desired cross section. Ask for Bulletin 563.

HEAT EXCHANGER GASKETS
Made in any size or shape needed in double-jacket type. Also cut from solid metal or sheet packing. Ask for Bulletin 564.

CORRUGATED METAL GASKETS
Plain or jacketed type. Made of ingot iron, aluminum, stainless steel, copper, brass, nickel and monel in all sizes and shapes. Ask for Bulletin 565.

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PRECISION PLATINUM THERMOMETERS

Illustrated Models

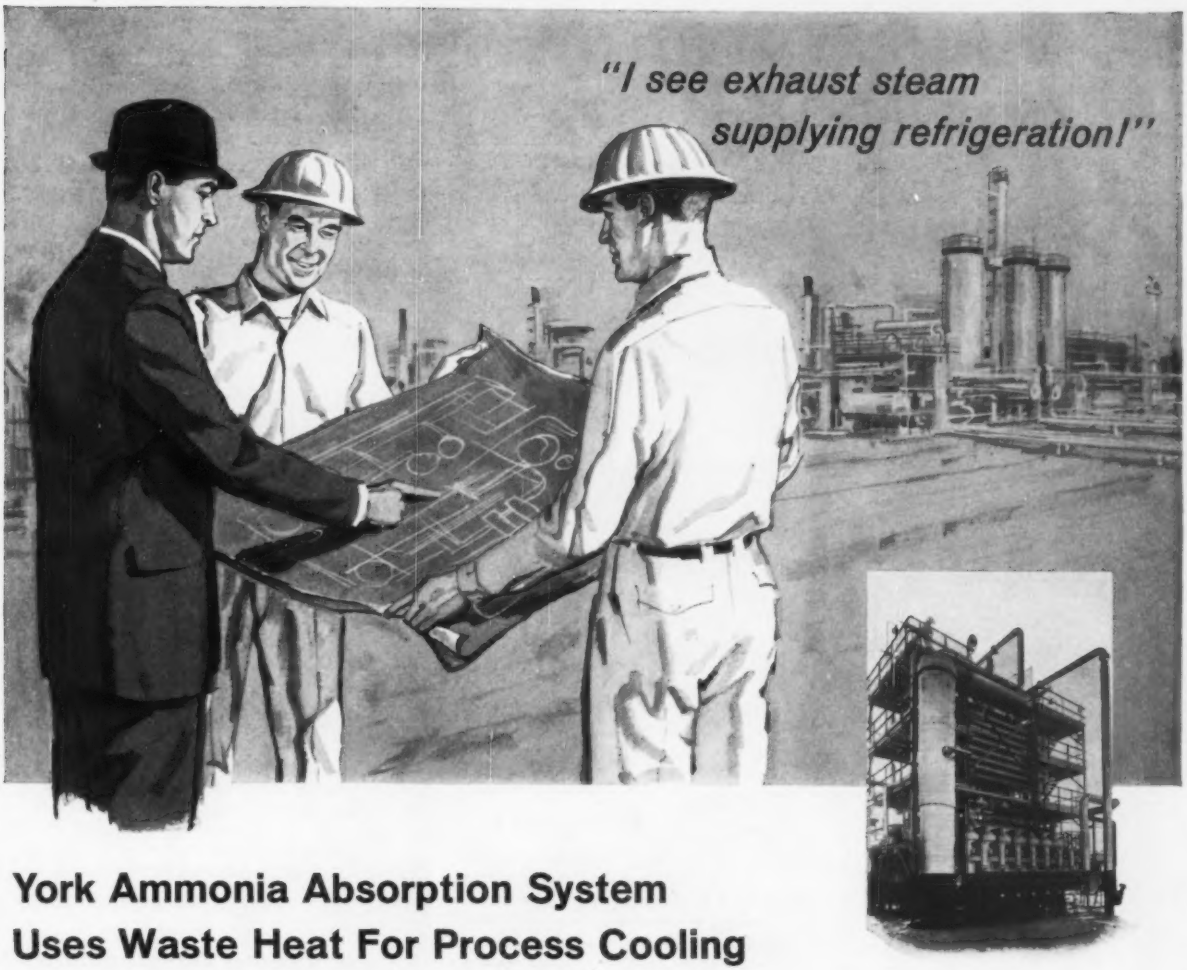
MODEL 162A Working standard thermometer. Stability is 0.01 C° over most of range from -182 C° to +260 C° (other models to -265 C° on request). Available on fast delivery.

MODEL 150B Miniature liquid hydrogen probe. The diameter is only 0.160 inches.

MODEL 134D Liquid oxygen probe. Widely used for Missile applications. High stability.

Write for New Catalog No. 115811 for description of 50 different REC probes, including total temperature probes and surface probes.

REC
ROSEMOUNT ENGINEERING COMPANY
4902 West 78th St.
Minneapolis 24, Minn.



York Ammonia Absorption System Uses Waste Heat For Process Cooling

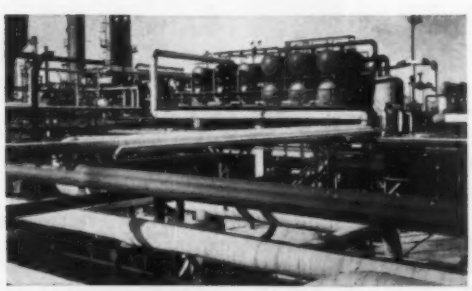
—Can operate unattended for long periods

VERY ECONOMICAL OPERATION—Utilizes exhaust steam from steam turbine driven equipment, hot oil, stack gases or waste heat from any source to provide refrigeration. Also can be direct-fired, if desired. York absorption units save substantially over conventional motor-driven compressor systems.

COMPLETELY AUTOMATIC—A few simple instruments control the system. These need no adjustment and are easily operated by average personnel. Flexible system operates from 100% to 0% capacity with almost constant efficiency, and is unaffected by sudden load changes and refrigerant "slop-over."

VIRTUALLY MAINTENANCE-FREE—Aqua ammonia pump is the only moving component in the entire system. This assures quiet, vibration-free operation and lowest possible maintenance. An extra aqua ammonia pump "spares" the system very economically and eliminates profit-cutting down-time.

INSTALLS OUTDOORS—Rugged construction eliminates need and expense of a building enclosure. Ideal for petro-chemical processing situations, or where indoor space is limited. Also adaptable for ammonia recovery. Capacities from 50 to 5,000 tons refrigeration for temperatures down to −90°F.



Another YORK Trail Blazer Concept Proved in Action at *Cities Service, Lake Charles, La.*—York Ammonia Absorption System uses waste heat from process vapors to deliver economical cooling at this Butadiene plant. Two-stage system provides 3,350 tons capacity—1,133 tons at 45° F. to cool spheroids and 2,217 tons at −5° F. for lean solvent cooling.

YORK

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5003 SOUTH GRANTLEY RD., YORK, PENNSYLVANIA

YORK B-W DIVISION

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MAKE IT BETTER

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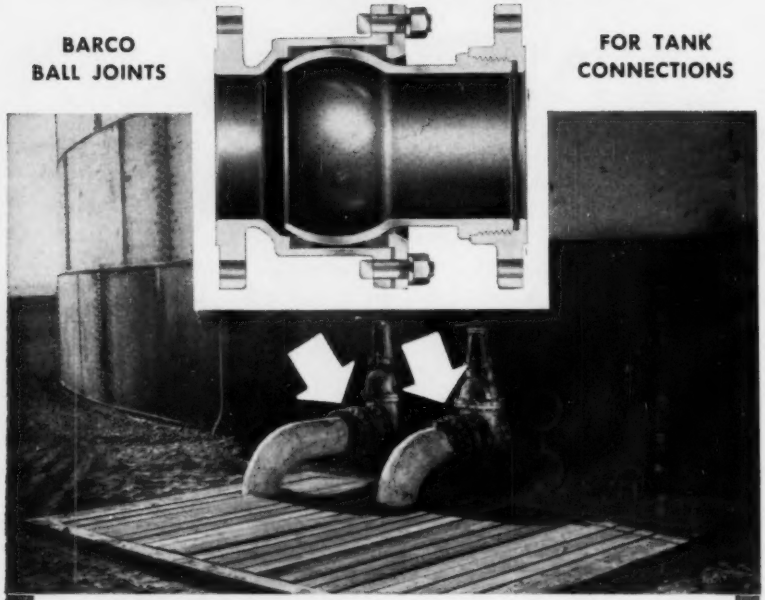
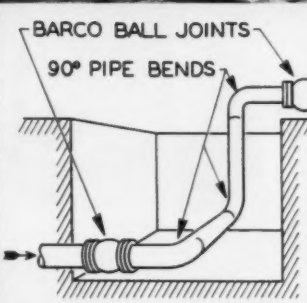
Built to Handle Big Tank Jobs!

BARCO BALL JOINTS

FOR TANK CONNECTIONS





FLEXIBLE!

This schematic diagram indicates the type of piping layout used to allow for up to 6 inches of tank settling or 6 inches of tank movement in any direction, and also for expansion or contraction of the long run of pipe leading to the tank. Similar piping is used for both 12" lines.

Barco Ball Joints—*Fire Safe!*

provide complete protection against FIRE, PIPE EXPANSION, TANK SETTLING

Major oil companies throughout the country now approve the use of Barco's new large size Flexible Ball Joints on tank connections for the following reasons:

1. Fire-safe. The joints have passed rigid fire and water spray tests.
2. Superior for handling pipe expansion—no combustible packing, no thin wall sections, no "end thrust" from pressure, no heavy pipe anchoring required.
3. Complete protection—relieve strain and twisting forces on valve flanges or tank wall.
4. Compact! Ideal for use inside narrow space between fire wall and tank. Easy to design piping for any amount of flexibility desired.
5. Also useful for insulating piping against electrolysis.
6. Long service life without maintenance. No lubrication. Sizes to 16"; flanged or welding ends.

For engineering recommendations, see your nearest Barco representative or write. ASK FOR CATALOG 215B and BULLETIN 31-A.

PRODUCTS BACKED BY EXPERIENCE BARCO FOUNDED 1908

BARCO MANUFACTURING CO.

5420 Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints

In Canada: The Holden Co., Ltd., Montreal

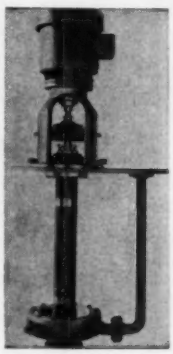
Equipment . . .

detect as little as five billionths of an inch of metal loss, the concentration of the corrosive compound can be extremely small, yet quickly detected. Thompson Ramo Wooldridge Inc.

Circle E15 green card, last page

Vertical Process Pump Handles Wide Liquid Range

A new line of vertical pumps known as Type pHV is available in 14 sizes. They range in capacity from 5 to 500 gallons per minute at heads from 10 to 120 feet and settings from 3 to 16 feet—inside or outside tank mounted.



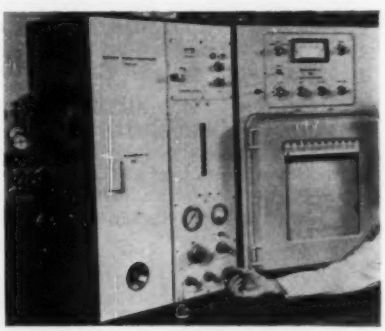
As in the horizontal line (Type pH), the new vertical pumps are also available in 17 alloys to meet practically all corrosive acid and caustic applications in a temperature range from —300° F to +750° F.

According to the manufacturer, the pumps are designed for highly versatile and economical application over a wide range of liquids, specific gravities and viscosities from light hydrocarbons to heavy slurries. Dean Brothers Pumps, Inc.

Circle E16 green card, last page

Advanced Developments In Chromatograph Analyzer

A new gas chromatography analyzer incorporating the most advanced developments, including Golay columns and ionization detectors, has just been introduced. Designated the Model 154-D Vapor Fractometer, the instrument features rugged mechanical and electrical components to meet requirements of longer and higher temperature analyses made possible by the new detector-column combinations. Proven design elements of the P-E 154 series have been retained to ensure optimum reliability, while obtaining unsurpassed sensitivity, resolution and



REPLACE STILL CONVECTION BANKS

WITH A **LJUNGSTROM® AIR PREHEATER**

You can make major economies in the refining of corrosive crudes, or in any refining that involves very high temperatures, by replacing still convection banks with a Ljungstrom Air Preheater. This is how.

The radiant section of your still, operating with an Air Preheater, can deliver as much throughput (and possibly more) as was formerly possible using convection banks. And with an Air Preheater the oil tubes get the maximum amount of heat without the expensive heat- and corrosion-resistant alloys sometimes required for convection banks.

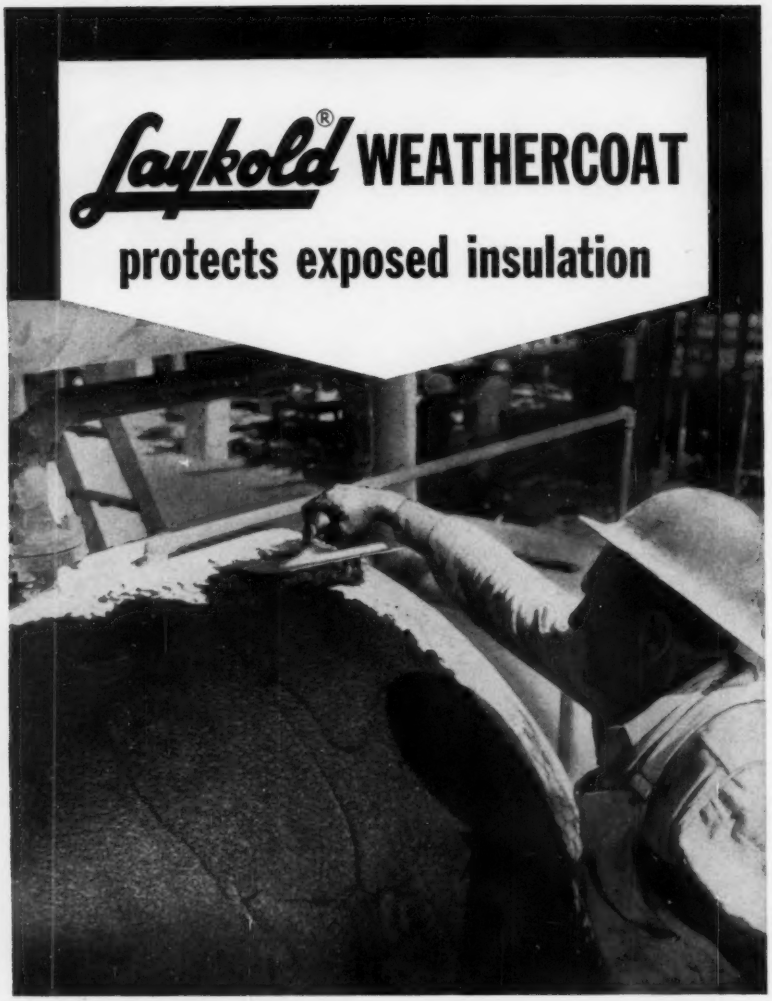
In addition, an Air Preheater provides other economies that you just don't get with convection banks. For example, an Air Preheater can cut fuel costs by 20%. It will promote high equipment availability by drastically cutting formation of slag and deposits. And an Air Preheater can take full advantage of the most modern fuel-burning equipment to give you much closer control of temperature—close enough to boost average product ratings as much as two octane numbers.

These extra savings can be almost pure profit, because you will probably save enough by eliminating or reducing convection banks to pay the cost of an Air Preheater installation.

Here's documented evidence. One company's fuel savings with a Ljungstrom Air Preheater are factually described in a published magazine article by O. F. Campbell. A reprint of this case history is yours free. Simply write to Air Preheater Corp.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.



INSULATION on towers, tanks and exchangers must be kept DRY. If moisture gets through, the efficiency drops.

Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

A new product: Mastic Weathercoat, a bodied material, for use wherever economy demands the application of a *single*, thick layer.

Write today for our free illustrated brochure, entitled "Laykold Weathercoat for Insulation Protection."

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Equipment . . .

versatility.

The most significant development in the new vapor fractometer is the realization of the potentialities of the Golay capillary column by the Flame and Beta-Ray Ionization Detectors. These new high-performance detectors permit accurate measurement of sample components in the minute quantities resolved by the Golay column. Standard interchangeable packed columns and thermistor, and hot-wire detectors are also available to give the Model 154-D an extremely broad range of application. Perkin-Elmer Corp.

Circle E17 green card, last page

Eccentric Valves Available With Plastic Faced Plugs

Eccentric valves thru 6-inch sizes are available with Viton-covered plugs. The resilient Viton facing in combination with eccentric action provides a dead-tight shut-off on highly corrosive liquids, gases, and slurries.

The physical properties of Viton make it an ideal plug-facing material. It does not cold flow; it is highly resilient insuring tight shut-off, and it is not damaged by slurry particles. The temperature limit for Viton is higher than most rubber compounds and on some services it can be used to 350° F. DeZurik Corp.

Circle E18 green card, last page

54-Page Insulation Catalog For Wide Temperature Range

Thermal insulations for all types of commercial and industrial requirements, in applications ranging from —400° F to 3,000° F, are completely described in a new 54-page catalog just published.

Information on each product consists of an application photo, description, available forms or types, advantages to users, and detailed specification data, including compliance with government specifications and ASTM standards. The type of insulation and its temperature limit are prominently displayed for each product to facilitate rapid location of pertinent data. Johns-Manville Corp.

Circle E19 green card, last page

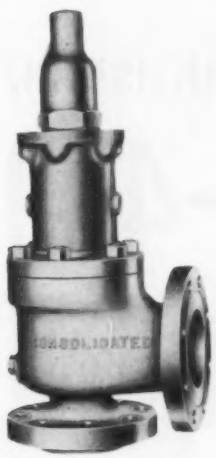
Chemical Cleaner Works Well on Fouled Exchangers

A new heavy-duty cleaner, designed to remove compounded carbon and asphalt soils from processing equipment, has just been released.

Combining solvent emulsion and alkaline properties, Composition No. 79 is recommended for use by circulation through closed systems in the range of 12 to 16 ounces per gallon of water, at temperatures up to 210° F. Its pH in use is 13.5 to 14.0, at the top of the alkaline scale. It is safe on steel and brass,

top

CONSOLIDATED SAFETY RELIEF VALVES have a special "O" Ring Seat Seal that stops leakage completely



Consolidated Safety Relief Valves are available in both Standard and Balanced Bellows design for extreme corrosive applications.

tightness

The Seal is a resilient ring set in the valve disc. It maintains no-leak tightness by contact with a specially curved seating surface on the valve nozzle, yet does not carry the seat load imposed by the valve spring.

Tightness is maintained at operating pressures far closer to set pressure than with metal-to-metal seats alone. Tight closure is as efficient after "simmer" as on normal blowdown. Piping strains are absorbed far better by the resilient seal than all-metal seating. If the tough seal is ruined by entrained abrasives, replacement is easy. Seals are available in materials that resist corrosive fluids. Maintenance costs are greatly reduced.

Standard Consolidated Safety Relief Valves have an eductor tube that removes pressure from the closed bonnet. Only the spring controls valve action. You get guaranteed capacity ratings and highest dependability—absolute protection for personnel and equipment. Additionally, there is the economy of converting the Standard valve to the Balanced Bellows type in your own shop. Get complete details. Write for Bulletin 1940.

MANNING MAXWELL & MOORE INC. TRADE MARK

CONSOLIDATED SAFETY RELIEF VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

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In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

NOW! A NEW CONCEPT IN COMPUTER DESIGN SETS A NEW STANDARD OF VERSATILITY AND VALUE!

THE FULLY-TRANSISTORIZED

RPC-4000 ELECTRONIC COMPUTING SYSTEM

For more data on advertised products, use Readers' Service Cards, last page.

The RPC-4000 is a new, fully-transistorized electronic computing system with the largest memory, greatest problem-solving capacity and flexibility in the low- or medium-priced field. It is the latest member of a growing family from the people whose LGP-30 has become the world's leading small-scale computer.

Wide range of applications: the RPC-4000 has been designed for engineering, scientific, business data processing and management control functions. Such jobs as product and process design, statistical analysis, research, inventory control, payroll and sales analysis are all well within its capabilities.

Easy to use: the RPC-4000 is simple to program and operate. Royal McBee compiling and translating routines allow even non-technical personnel to obtain maximum results. Versatile command structure gives programming speed and flexibility.

Available at low cost: high capacity, flexibility and ease of operation make the RPC-4000 the outstanding computer value on the market today.

Minimum operating costs: the RPC-4000 requires no site preparation or special maintenance. It is powered from any ordinary wall outlet.

Continuing assistance: users benefit from free training, an information exchange service, and library of programs.

Heart of the RPC-4000 system is a new transistorized computer with advanced design concepts that provide substantial computing speed and capacity in a low-cost unit. Magnetic memory drum stores *8008 words*. Operating speeds are as high as 230,000/minute.

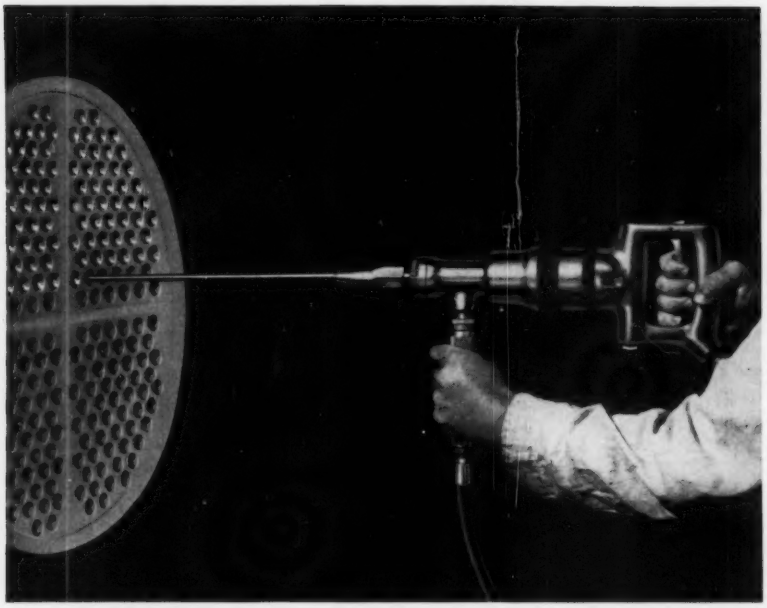
Standard input-output is a tape typewriter system which includes a Royal electric encoding-decoding typewriter complete with desk and chair, plus a tape punch-read console. Read speed is 60 characters/sec., punch speed 30 characters/sec. Typewriter, punch and reader may be interconnected in any combination for both on-line and off-line operations.

A new 500 character/sec. photoelectric tape reader and a 300 character/sec. punch are available as optional input-output equipment. A magnetic tape unit and a line printer will be available soon. As many as 17 input-output devices (60 with minor modification) may be connected on-line to the basic system. All peripheral equipment is under automatic program control of the computer.

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. RPC-4000 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing Offices. For full, detailed specifications on the new, transistorized RPC-4000, write **ROYAL McBEE** data processing division, Port Chester, N.Y.

For more data on advertised products, use Readers' Service Cards, last page.



One man handles this powerful Airetool tube cleaner...without a rig

There's no other tool like this Airetool Model CC-475 heat exchanger and condenser tube cleaner. It weighs just 10 lbs. One man handles it easily — without a supporting rig. Yet, it's powerful enough to clean all severely clogged tubes up to 1″ diameter. Built-in flushing system washes away debris, cools drill head — keeps work moving at a fast pace.

You get this same time and cost-saving performance from Airetool straight tube cleaners and pneumatic, as well as electric tube expansion control systems. Write for Bulletin 66. *The Airetool Mfg. Co., Springfield, Ohio*

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SPRINGFIELD, OHIO

Equipment . . .

but its high alkalinity precludes its use where other metals are involved. The compound may also be used in well-ventilated open tanks at temperatures up to 150° F.

In field tests, the compound has proved effective in cleaning heavily soiled heat exchangers, bubble caps and trays, and stripper towers. Oakite Products, Inc.

Circle E20 green card, last page

Liquid Level Control Made Entirely of Plastic Parts

Low-cost liquid-level controls in which all parts of the control in contact with liquids or vapors are polyvinyl chloride are available. The new NM-1 and NM-2 Magnetrols are used in controlling liquids that present problems in handling.

Advantages of the new models are: immune to galvanic or electrolytic attack; corrosive resistant; immune to oxidizing agents; smooth surface discourages any tendency to scale or act as host for deposits; will not contaminate or impart odors or tastes to the liquid.

The two new models are for use in controlling any liquid of specific gravity 0.70 or above. Chamber and float construction are for service at 100 psi at 70° F, or 50 psi at 140° F. Magnetrol, Inc.

Circle E21 green card, last page

Fractionating Tray Seals Described In New Bulletin

A new bulletin is the latest revision describing METEX high-temperature liquid seals, applicable for sealing fractionating trays in all types of process equipment to temperatures as high as 900° F. METEX Tray-Seal is now available in 12 different types and can be obtained with monel, stainless steel or inconel wire binder. Metal Textile Corp.

Circle E22 green card, last page

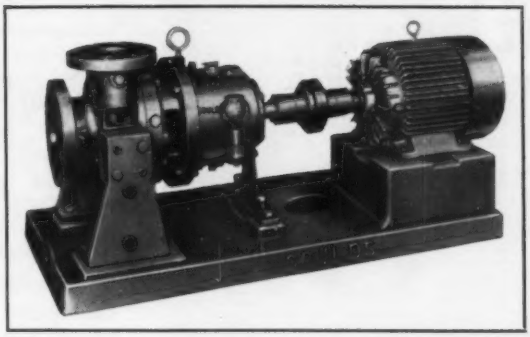
Folder Covers Two Steels Suggested As Standard

The varied requirements of industry have resulted in a bewildering assortment of alloy tubing steels, each with its particular characteristics. Selection of the correct grade of alloy steel for each tubing application, and the stocking of adequate quantities of each, pose major

THIS IS INTERMEDIATE-RANGE DESIGN

Robert Fornesi, Senior Application Engineer, Goulds Pumps, Inc.

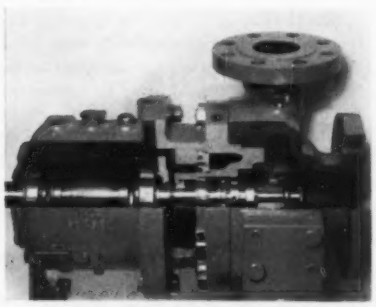
Changing requirements created this third dimension in process pump selection



Once upon a time you had to meet petroleum process applications with pumps in only these two ranges: (1) Light duty pumps to handle temperatures up to 200° or at most 300°. (2) Real heavy duty pumps for 200° to 800°. That's changed.

Here's why. Goulds product development group appraised the growing range requirements and services of petroleum process pumps. They found that 200° was no longer a realistic dividing line for process pump types. The need was for one pump which would handle all light duty applications and the growing number of intermediate applications as well.

Why should you have to buy a light duty pump with built-in temperature limitations when an intermediate-range pump could be built for almost the same price? Why should you pay for an 800° heavy duty pump to handle all the applications above 200° or 300°?



THIS DESIGN SOLVES HIGH TEMPERATURE SEAL PROBLEMS

Goulds designers felt they had the answer to both these questions in their plans for the Model 3775 line. This was not enough.

The design concept was verified by field research. The plans were rolled up from the drawing board and flown and shown all over the country. Plant superintendents and operating engineers saw them. They said yes.

They liked the rather obvious ideas that made INTERMEDIATE DESIGN POSSIBLE . . . the mechanical seal isolated in a seal chamber. This to allow for cooling of the liquid within the seal chamber. It made higher temperature handling with mechanical seals possible as it protected the seal. In similarly priced pumps the mechanical seal area behind the impeller is wide open. The hot pumpage is in constant contact with the seal. With the Model 3775 seals are not exposed to direct contact with hot pumpage. Cooler seals mean longer seal life.

COOLED CASING SUPPORT . . . A PLUS FEATURE

This was not enough. To be completely fit for INTERMEDIATE-RANGE (up to 650°) applications the Model 3775 had to have these features of costlier heavy duty pumps—cooled bearings and casing support.

Goulds Model 3775 has them all—water-cooled bearing housing and casing support as well as the seal chamber. This plus the choice of either internal or external flushing of the seal chamber. Single, double, balanced or unbalanced seals available to properly fit the application.

The pump is back pull-out type for easy maintenance. A spacer coupling allows you to remove the rotating parts without disturbing pipe connections or driver.

Built in accordance with API 610 specs, the fine mechanical features of this pump provide a husky line of pumps with maximum standardization and interchangeability of parts. Eleven sizes are built on the same bearing frame.

The Model 3775 is a horizontal center line mount with vertically split casings. Renewable casing wearing rings maintain proper clearance with impeller wearing rings. Leakage between suction and discharge chambers of the casing can be held to an absolute minimum.

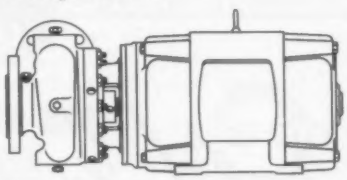
Talk over your process handling methods and problems with your Goulds engineer. He'll show you many more reasons why the INTERMEDIATE-RANGE 3775 is your best process pump choice for the majority of applications . . . *why it makes light duty pumps obsolete.* How it better fits the growing range of your process requirements.

AND AT LAST . . . A CLOSE-COUPLED PROCESS PUMP!

Goulds Model 3675 is the close-coupled version of the 3775. These units use the same liquid end as the frame mounts. The 3675 casing may be swiveled to four different discharge positions.

This integral pump-motor design provides the maximum in economy and compactness. Flexibility, too! One of our customers changed a process. A steel-case pump was required. Buy all new units? No, Goulds Model 3675 liquid ends fitted on the customer's present motors and provided the same rating. Only the casing was changed.

Get the complete story on these new pumps and all the others in the modern Goulds line. Send our factory the coupon below.



GOULDS PUMPS

GOULDS PUMPS, INC. Dept. PR-30, Seneca Falls, N.Y., U.S.A.

Send me a bulletin with complete application data on your INTERMEDIATE-RANGE DESIGN petroleum process pump.

Anything else? Please check.

- ☐ 1-stage centrifugal—Model 3405
- ☐ 2-stage centrifugal—Model 3305
- ☐ Steel case Pumps Bulletin

NAME _____ DEPT. OR TITLE _____

COMPANY _____ ADDRESS _____

CITY _____ ZONE _____ STATE _____

For more data on advertised products, use Readers' Service Cards, last page.

WE WEAVE ACCURATE "WORKING OPENINGS"

IN WOVEN WIRE SCREEN AND WIRE CLOTH PRODUCTS

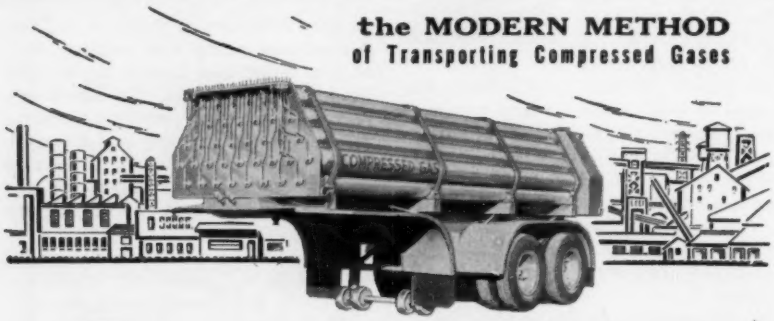
Whether you are grinding, sizing, scalping, dewatering or filtering it's the accuracy of the "working opening" that makes the difference in woven wire screen and wire cloth products. We pride ourselves in weaving accurate "working openings", an engineered screening surface to meet your specification.

First, the best metal or alloy is selected—hard enough to withstand the abrasive action—ductile enough not to break under stress. Next, the best wire diameter and crimp are determined. Then we weave wire screen or wire cloth around accurate "working openings" best suited for your screening application.

FREE! Write for bulletin 160 giving complete details and facilities.

THE CLEVELAND WIRE CLOTH & MFG. CO.
3571 EAST 78th STREET • CLEVELAND 5, OHIO

the MODERN METHOD of Transporting Compressed Gases



INDEPENDENT ENGINEERING CO. — IECO

gas supply TRAILERS *tailored just for* **YOU**

- MANIFOLD & CONTROLS — for YOUR Gas and Handling Requirements
- CAPACITY — to meet YOUR Requirements
- SAFETY — Cylinders, Safety Devices, Controls etc., All in accordance with ICC Requirements for YOUR Protection.
- CHASSIS — by leading Chassis Manufacturers with Service Branches throughout the United States for YOUR Convenience.

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Manufacturers of CYLINDERS AND GAS PRODUCING EQUIPMENT
ACETYLENE · OXYGEN · NITROGEN · ARGON
O'FALLON 6, ILLINOIS

Equipment . . .

problems to design engineers. Such problems can be substantially reduced by standardizing.

A folder just released discusses two general-purpose steels which lend themselves very well to such standardization: # 4340, a thorough hardening steel, and # 4620, a case hardening steel. General characteristics and technical data covering these two grades are discussed at some length in the folder. Tubular Products Div., The Babcock & Wilcox Co.

Circle E23 green card, last page

Compact Piping Valve for Block and Bleed Service

A new, extremely simple and compact valve for general pipe line and manifolding service has been developed. It is available in both lever-operated and hand-wheel operated models—in sizes ranging from 2 to 36 inches.

The lever operated version is quick opening and the hand-wheel model is equipped with double-acme threads for fast action. The new valve provides a seal on the upstream and downstream sides of the gate. For block and bleed service the G-5 offers a reduction in hook-up costs by eliminating one valve and a spool previously required in such assemblies.

Metal seat rings are in constant contact with chrome-plated body side plates, guaranteeing continuous scraping action through all gate positions. In addition, a patented application of nitrile rubber O-rings provides squeegee action to keep the side plates clean and cut down maintenance costs by eliminating the need for lubrication. Grove Valve and Regulator Co.

Circle E24 green card, last page

Heat Exchanger Catalog Includes Selection Data

A new 15-page revised shell and tube heat exchanger catalog presents complete data on copper base alloy, steel and stainless steel fixed tube bundle heat exchangers. It includes single-pass, two-pass and four-pass models for cooling water and oil in fresh or salt water applications, as well as specially engineered heat exchangers for heating or cooling liquids and gases.

The catalog lists tables showing pressure ratings and material specifications for steam-service heat exchangers. Con-

over multiple source buying of YOUR laboratory needs

Make Curtin your one reliable source for laboratory supplies. Complete stocks of quality laboratory equipment are maintained for immediate delivery at supply points strategically located in all major refining areas. Technical and Repair Services are readily available all the time to help with your specific problems. Call Curtin on your next laboratory order and get "everything at one source."

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Established 1922 U.S.A.

Now! More Dead Weeds and Brush per Dollar

with **UROX®** WEED KILLER

One Application Gives 8 to 18 Month Control!

Here's the weed killer you can *positively depend on* to wipe out weeds and brush faster, easier, at lower cost and for a longer time than you ever thought possible. Urox weed killer effectively handles weed killing jobs along pipelines, on tank farms, around refineries and pumping stations, where weeds and brush are a constant fire hazard. In all these places, *just one application of Urox weed killer will remain effective for as long as 8 to 18 months!*

Longer lasting! Saves time and money! Urox weed killer has a cumulative effect on weeds and brush. Its herbicidal action can thus be extended from one year to the next with light booster doses. As smaller amounts are used over a period of time, you realize substantial savings.

Easy to use! *Liquid Urox* weed killer is ideal for spraying large overgrown areas. It won't clog spray nozzles or strainers! Won't precipitate out in the tank! Stays in solution perfectly! *Granular Urox* weed killer is the convenient inexpensive way to treat small weed-infested areas. Can be applied easily with any mechanical or hand-operated spreader.

New Urab® weed killer kills deep-rooted brush and weed trees! If you have problems with tough, deep-rooted weeds, brush or weed trees, *New Urab Weed Killer* is just what you're looking for. Urab weed killer actually *penetrates soil* to kill deep roots. Does what no other herbicide can! Supplied in liquid and granular forms.

*Trademark of Allied Chemical Corporation

Get the whole story! Mail this coupon!

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

Weed Killer Dept. PR-30
GENERAL CHEMICAL DIVISION
Allied Chemical Corporation
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☐ Please send me more information about General Chemical's amazing new herbicides, Urox and Urab.
☐ Please have representative phone for appointment.

Name_____
Title_____
Company_____
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City_____ Zone_____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

A UNIQUE CHECK VALVE THAT'S UNSURPASSED IN WATER, AIR, OIL OR GAS SERVICE

SILENT • SEATLESS • LOW PRESSURE DROP

Technocheck®

OUTPERFORMS • OUTWEARS OTHER VALVES • COSTS LESS TO MAINTAIN

In field service in a wide range of water, gas, air and oil applications, Technocheck's performance and reliability are unsurpassed. Its exclusive design eliminates valve seats. Tight sealing, low pressure drop and long life with low upkeep are some of its important characteristics.

SCHEDULE OF STANDARD VALVE SIZES

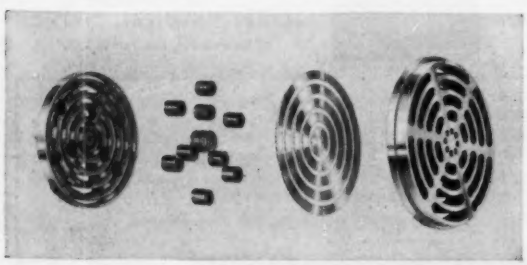
GENERAL DESCRIPTION	PSI	SIZES
Cast Iron, Flanged	125	4", 6", 8"
Steel, Male Threaded Ends	150	1½", 2", 2½", 3"
Steel, Flanged	150	3", 4", 6", 8"
PVC, Male Threaded Ends	125	1½", 2", 3"
PVC, Flanged	125	2", 3"
PVC, Flanged	50	4", 6", 8"

We invite inquiries on other sizes and in special materials.

Techno Corporation Dept. PR
16 West 5th Street, Erie, Pa.

VOSS VALVES will mean LESS MAINTENANCE FEWER SHUTDOWNS for your COMPRESSORS

Voss Valves are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. Plates are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. Springs of heavy rectangular sections and large diameters add to dependability and safety.



- up to 40% more valve area
- minimum pressure loss
- higher efficiency
- less power consumption
- normal discharge temperature
- quiet, vibration-free
- utmost safety
- lower operating costs

For detailed proposal send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street,
New York 54, N. Y.

Equipment . . .

struction features, model identification and a 6-step set of instructions explain the selection of heat exchangers. An oil viscosity graph, a table of weights and dimensions and product guarantee complete the catalog. The Young Radiator Co.

Circle E25 green card, last page

Fuel Additives Reduce Fuel and Diesel Oil Sludge

A new line of fuel additives will carry the trade name Tolad.

Two types of Tolad fuel-oil additives are available. They are the inhibitor or preventive type and the inhibitor-dispersant type.

The inhibitor type additive is usually most effective for fuels intended for use in domestic heating units or in applications where maximum reduction of insoluble residue and sludge is of prime importance. The inhibitor-dispersant additive is usually preferred for diesel fuels. This type additive, besides reducing the quantity of insoluble residue, also reduces residue particle size. Tretolite Co.

Circle E26 green card, last page

Form Used To Select Most Efficient Heat Exchanger

Selection Data Form can be used to obtain precise information regarding the most efficient size and type of heat exchanger required for a particular operation.

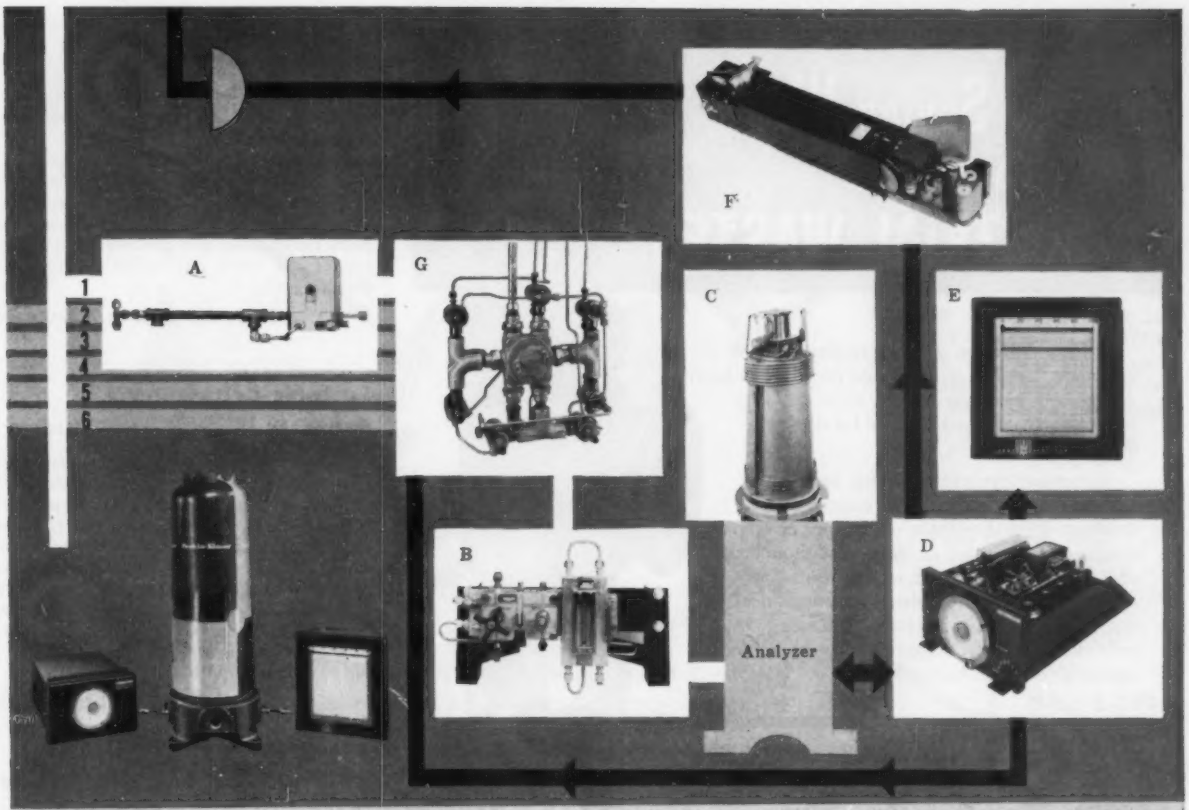
The new Selection Data Form covers a complete line of equipment, including a package regenerative air preheater designed for industrial process or boilers in a range from 25,000 to 250,000 pounds per hour. It covers recuperative-type heat exchangers engineered for high temperature, high pressure applications where leakage cannot be tolerated. A compact rotary regenerator available in a range of sizes starting as small as 20 inches in diameter is discussed. The Air Preheater Corp.

Circle E27 green card, last page

New Pneumatic Transmitter Described In Bulletin

A bulletin just published describes a line of new Pneumatic Transmitting Rotameters.

Designated SK "Model 58," Pneumatic Transmitters, these "position-balance" type instruments transmit an air signal proportional to fluid rates of flow to remote-located indicators, recorders, controllers, or integrators. These Pneumatic Transmitters are designed for use with either glass-tube or metal-tube Rotameters. They are mounted directly on, and



Stream flow lines shown in white, signal paths in black

This block diagram shows how six process streams can be selectively analyzed by the P-E Model 184-B. For brevity, Stream #1 only will be followed through the system.

Stream #1 is tapped, and the sample vaporized in the Liquid Sample Vaporizer (A). Sample #1 then flows (with the other five vaporized samples) into the enclosed, heated Multi-Stream Solenoid Switching Manifold (G). The solenoids are electrically directed by the Programmer (D). As it is selected, Sample #1 is valved into the Final Sampling Assembly (B), where it is filtered and metered into the Analyzer. The Analyzer quantitatively and qualitatively separates the sample's components by gas chromatography, produces signals which appear as a bar graph on Recorder (E).

The signal can also be fed into a Pneumatic Control Accessory (F) which produces a 15 psi signal for automatic control of one variable component of the stream.

The Analyzer with Reverse Flow Valve (C) allows for the analysis of light components individually plus a "total heavies" measurement; it back-flushes and analyzes heavy ends as a single peak, shortening analysis time in the process. The Programmer (D) is available in a variety of modes for multi-component and multi-stream analysis. It controls the Switching Manifold (G) and the Analyzer, and the read-out of the Recorder (E).

All flow lines and sampling building blocks are kept above the dew point, where necessary, by steam tracing.

UNTIL NOW—PROCESS CONTROL INSTRUMENTATION LIKE THIS HAD TO BE CUSTOM-BUILT

Standard building blocks give the new P-E Model 184-B Process Vapor Fractometer the flexibility of the most advanced special engineering developments in process gas chromatography.

A new, highly versatile instrument, the Model 184-B brings automatic process control by gas chromatography within the reach of virtually any petroleum or chemical processing plant.

The Model 184-B uses *building block* sampling and sensing units in various combinations to produce process analytical systems which mean continuing extra dividends through reduced maintenance, low-cost training and highest reliability.

These standard building blocks include multi-port sampling valves for backflushing and analyzing heavy ends . . . versatile multi-column systems . . . multi-stream programmer kits . . . pneumatic units for automatic control . . . and a wide variety of sampling devices.

Perkin-Elmer, the world's largest manufacturer of gas chromatographic instruments, will help you in your process instrumentation requirements. For more information, write for a new descriptive booklet.

All building blocks in any P-E system conform to standard refinery and chemical plant safety practices.

Talented engineers and physicists at all levels interested in development of commercial laboratory scientific instruments find great reward at Perkin-Elmer. Please write or call Mr. Howard Moran.

INSTRUMENT DIVISION

Perkin-Elmer *Corporation*

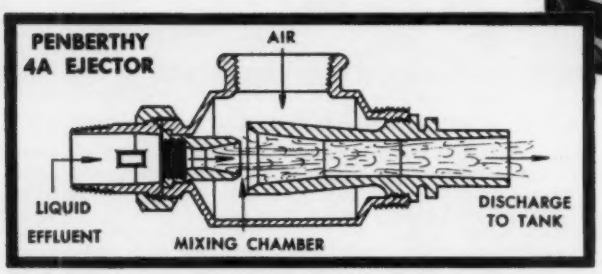
NORWALK, CONNECTICUT

For more data on advertised products, use Readers' Service Cards, last page.

Money-Saving Way To Handle INDUSTRIAL WASTES

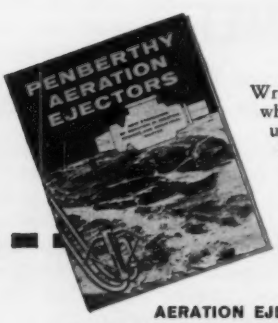
Where pollution and waste-disposal are problems, the activated sludge process has been recognized generally as the most effective way to make effluents suitable for discharge into streams, sewers, etc.

Successful operation of this system depends upon efficient and economical aeration — the dispersion of millions of tiny bubbles of dissolved oxygen throughout the solution. Compared to the 4 to 5% absorption by porous plates on mechanical systems, Penberthy Aeration Ejectors provide 20 to 25% oxygen absorption while using 40% LESS horsepower.



This remarkable efficiency of Penberthy aeration over older methods is being demonstrated in actual installations every day. It is simple to design, install and operate ... and costs much less for all three.

Penberthy aeration systems can be designed by any competent engineering staff to suit any aeration requirement. Equally important, they offer a practical means to expand present capacity without expanding existing tank volume.



Write for a copy of our new brochure which contains practical information useful in planning, installing and cost-estimating new or expanded facilities. You will also find our engineering staff helpful with your specific problems.

AERATION EJECTORS by
PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
Prophetstown, Illinois

There's certain satisfaction in **PRODUCTS BY** PENBERTHY

- EJECTORS
- INJECTORS
- CYCLING JET PUMPS
- ELECTRIC SUMP PUMPS
- LIQUID LEVEL GAGES
- GAGE VALVES

Equipment . . .

are magnetically coupled to the Rotameter to sense the Rotameter-measured fluid rate of flow.

The bulletin includes photos, sectional drawings, and information on materials of construction, operation and application. Characteristics of the transmitter unit, dimensions and maximum capacity ranges are also included. Schutte & Koerting Co.

Circle E28 green card, last page

Sulfuric Acid Filter Protects Pump From Sludge

Pumps metering commercial grades of sulfuric acid in volumes of less than 20 gallons per hour should be protected from sludge. Bulletin 459 describes a specially designed sludge trap and filter which effectively traps and removes concentrated sulfuric acid sludge. This allows highly accurate controlled-volume pumps to work at peak efficiency. Design features, operation, and diagrams are carefully explained. Milton Roy Co.

Circle E29 green card, last page

28-Page Catalog Tells How Metering Pump Can Be Used

A new 28-page catalog is available, which describes the use of Pulsafeeder metering pumps in process industries. The catalog tells how the pumps can be used, types of hard-to-pump fluids which the metering pumps can handle, a detailed description (with drawings) on how the pump works, and various types of reagent heads available for effective metering of difficult fluids. Lapp Insulator Co., Inc.

Circle E30 green card, last page

FOR OIL AND PHENOL ANALYSIS
in water effluents

Now the ULVIR-MOD 2834 makes possible rapid analysis using API methods 717 and 733. This "colorimeter type" spectrophotometer is equipped with an

f 4/5 optical system
9 millimicron bandwidth
at a cost of only $1,800.

For detailed information, write for circular 34.

XLER SSOCIATES. INC.

Manufacturers of Precision Optical Instruments, Filters and Thin Films

HAvemeyer 9-7718

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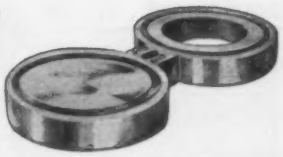
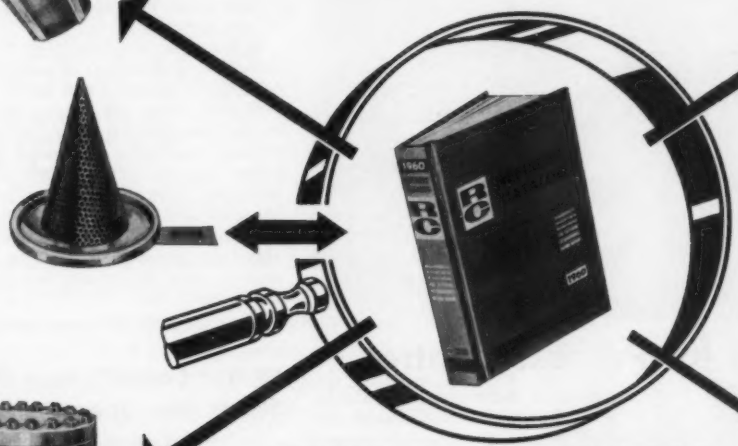
For more data on advertised products, use Readers' Service Cards, last page.

MASTER PRODUCTS and CATALOG!

All MAC-IRON stock items, complete with detailed specifications, are listed on pages 653 through 660 of the newly released 1960 Refinery Catalog for your immediate reference.





MAC-IRON CATALOG A-9

Although you'll find our full line Catalog A-9 in the 1960 REFINERY CATALOG wouldn't you like more copies for distribution among your important engineering personnel?

Your request will bring all the copies you need. WRITE TODAY . . .

THE MACK IRON WORKS COMPANY
121 Warren Street
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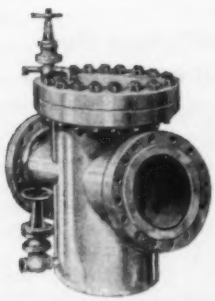


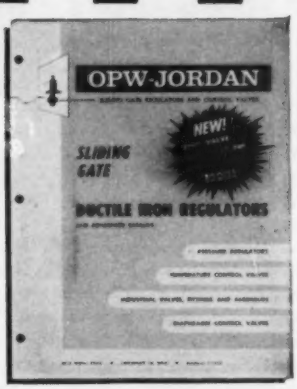
SPECIALISTS TO PETRO-CHEM-REFINING AND CHEM-PROCESS INDUSTRIES SINCE 1901

Stock and custom made items for many engineered applications which involve pumping of fluid materials and operational liquids.

BLINDS • SPACER RINGS • STRAINERS • PIVOT FLANGES

NEW

REGULATORS AND CONTROL VALVES NOW AVAILABLE IN DUCTILE IRON



This easy to use manual describes how you can get steel strength in regulators and control valves at the cost of iron . . . and, at considerable savings. It fully explains how ductile iron is produced, shows features, specifications, typical ranges of mechanical properties, and comparison tables on physical properties of cast steel, ductile iron, red brass and cast iron. This manual is also a condensed catalog describing the complete line of OPW-JORDAN products that are available to you in ductile iron. It's available for the asking . . . so, send for your Ductile Iron Manual today!

Send for your Copy!

OPW-JORDAN
6013 WIEHE ROAD
CINCINNATI 13, OHIO

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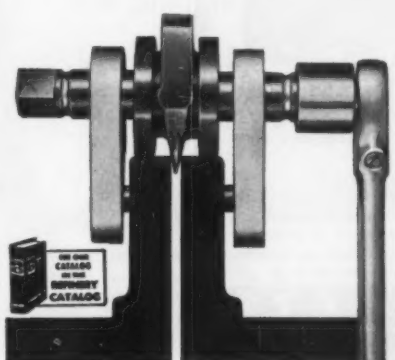


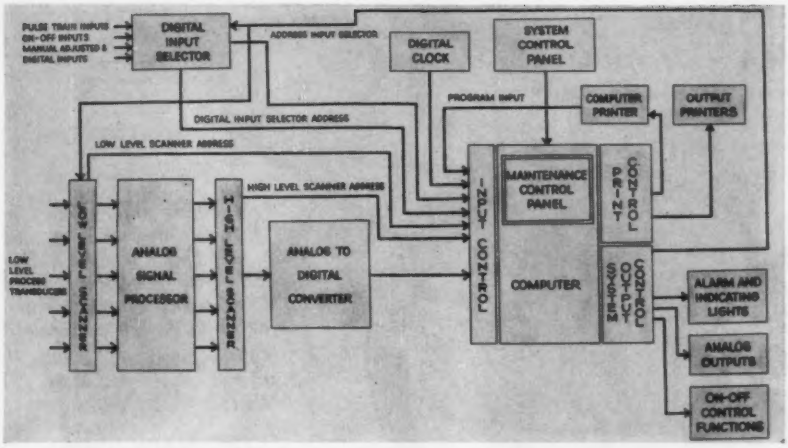
A PIPE DREAM COME TRUE

"SAFETY BOY"

AT LAST! A TOOL TO SPREAD PIPE FLANGES SAFER — FASTER — MORE ECONOMICALLY — IN TIGHTEST WORKING SPACE.

For Catalog Sheet, Write:
Wm. L. Riggs Co.
600 S. 129th E. Ave.
P. O. Box 5002
Tulsa, Oklahoma

With a "Safety Boy" you can spread all types of flanged pipe connections **in seconds,** not hours — to insert blinds, gaskets, orifices. Plant safety hazards and costly down time are eliminated by switching to this really modern pipefitter's tool — "Safety Boy." Wherever there's piping there's a need for "Safety Boy" — the handiest tool ever invented for work in cramped quarters. Lightweight and easy-to-carry, "Safety Boy" is reasonably priced for wide usage.



Computer Designed for Process Control

The first description of the LN-3000 digital computer for control of industrial process has been released. Depending upon the particular on-line application, a system incorporating the computer may perform any one of the following three general functions:

• On-line data reduction and calculation of operating guides. A system of this type would permit open-loop control based upon performance criteria consisting of complex algebraic relationships between the process variables. Control by use of such performance criteria would normally be impossible due to the length of time it would take to perform the necessary calculations manually. This type of system could also be used to study a particular process of which little may be known.

• Program Control. A program control system incorporating a digital computer could be used in applications that involve a complex series of yes or no decisions, such as process start-up and shut-down. Such a system could be either completely automatic, or the results of computer decisions could be displayed as instructions to the operator.

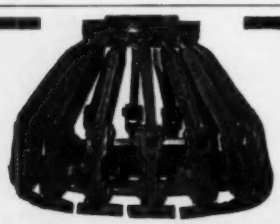
• Supervisory Computer Control. In this type of system, the computer would be used to calculate and set the optimum reference levels for local analog control loops. Computations would be based upon process equations, if known. The computer may be programmed to seek out optimum controller settings by performing carefully designed experiments upon the process itself. This type of system may also be expanded to perform automatic start-up and shut-down functions. Leeds & Northrup Co.

Circle E31 green card, last page

Water Conditioning Data Sheet Has Been Released

A new water-conditioning data sheet entitled "A Modern Approach to Cooling Water Treatment," has been released. This informative technical discussion covers the Dianodic method of corrosion control and how it has revolutionized the treatment of open recirculating cooling water systems. Betz Laboratories.

Circle E32 green card, last page



BARRETT automatic
Filling and Crimping Equipment
for handling greases and other viscous fluids.
• No operator required.
• 100% air operated.
Fills, seals, stamps and counts lug cover pails. Output of 15 pails per minute. Write for details on installation to meet your requirements.
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REFRACTORY HAYDITE
Makes Higher Heat Resistant Concrete
Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
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CONTROL ENGINEERS
CHEMICAL ENGINEERS
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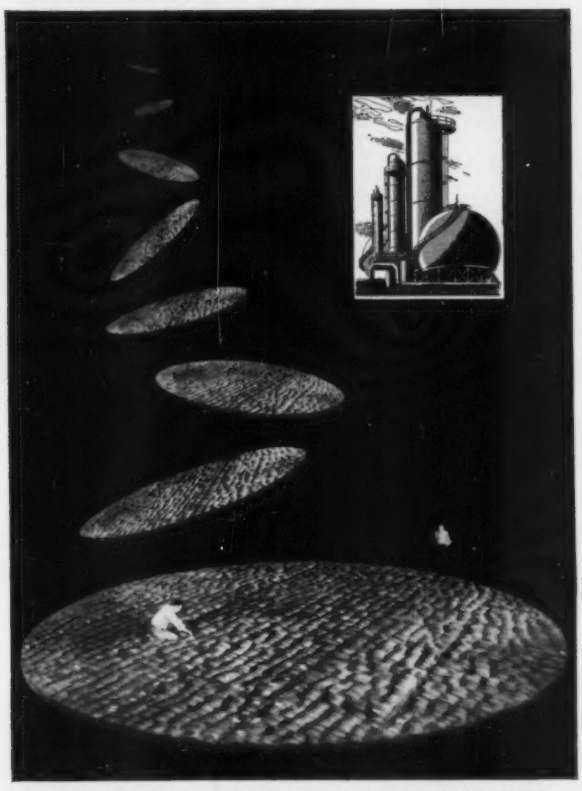
The Thompson-Ramo-Wooldridge Products Company is seeking chemical, electrical, or mechanical engineers with training or experience in process or control system analysis, analog or digital computers, and instrumentation. Staff members at TRW Products work in small teams designing and evaluating RW-300 computer control systems for the process industries. Experience in the petroleum refining, chemical, steel, or electric power industries is particularly desirable. Applicants with advanced degrees are preferred. Those interested are invited to call BRadshaw 2-8892 or write:
Dr. Thomas M. Stout, Process Analysis Department Manager
THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS COMPANY
a division of Thompson Ramo Wooldridge Inc.
202 North Canon Drive • Beverly Hills, California

No liquid carry-over problem is ever too great for METEX!

In installation after installation...in all types of processing equipment—Metex mist eliminators are knocking back liquid entrainment...upping production...improving quality...cutting operating and maintenance costs. ■ Your particular entrainment problem is no exception. For at Metal Textile we've been knitting low-cost answers to such problems since 1943. As the originators of knitted wire entrainment separators, Metal Textile has the engineering experience—and the research and production resources necessary to support that experience—to take on even the most difficult liquid entrainment problems. Our engineering department stands ready to help you solve your particular problems with complete design assistance. For latest design guides, write or call for Bulletin ME-9: Metal Textile Corporation, Roselle, N. J.



METAL TEXTILE CORPORATION
...world's largest and oldest producer of knitted wire products
A DIVISION OF GENERAL CABLE CORPORATION

As SIMPLE and Dependable as the Pull of a MAGNET!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.

MAGNETROL

The Simplest, Most Versatile LIQUID LEVEL CONTROL Ever Devised!

Linked to liquid level by infallible magnetic force, Magnetrol is free from the limitations inherent in mechanical or electrical controls. With the actuating magnet rated at 98% of initial strength after 30 years, Magnetrol has *infinite operating life,* with practically no maintenance at all. There are no wearing parts to get out of order.

What's more, Magnetrol's simple operating principle permits easy, economical modification of standard units to meet *any* pressure, temperature or corrosion requirements. That's why there's practically no limit to Magnetrol's use. It's also why "specials" are likely to be standard with us. Magnetrol units control level changes from .0025-in. to 150-ft. —with single or multi-stage switching.

MAGNETROL, Inc.

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